THE STORY OF THE HUMAN BODY

A READER IN HYGIENE FOR PUPILS IN FORM III. OF THE PUBLIC SCHOOLS

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"Full of life and energy" (p. 8).—[A Summer Camp, by C. W. Jefferys.]

THE STORY OF THE HUMAN BODY

A READER IN HYGIENE
FOR PUPILS IN FORM III.
OF THE PUBLIC SCHOOLS

BY

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THE STORY OF THE HUMAN BODY

CHAPTER I

HEALTH

When we meet a friend whom we have not seen for some time, we usually ask him, "How are you?" If we express our good wishes for any one, the most common wish is for good health. At banquets a very old custom is still in use—that of "drinking to the good health" of some one whom the company wishes to honour. "The health of the King" is usually the first "toast," as it is called, at such a gathering. In Germany there is a quaint old custom that when one sneezes those who are with him say "Good health!"

Good health is what we most commonly wish for our friends, and it is one of the greatest blessings which we can desire; it is worth more than wealth or fame. Have you ever thought what "health" really means? The word comes from the old Anglo-Saxon speech of our forefathers, and it means *wholeness* or completeness. An older form of "whole" is *hale*. We still use this word in speaking of an old man who, in spite of his years, is always well and full of energy; we say he is a "hale old man," one who is still "whole" or in good health.

Health or wholeness means freedom from disease, but it means more; it also means that the body is full of life and energy, of strength and vigour. We say "How healthy he looks!" when we see a little boy whose cheeks are fresh and rosy, whose eye is bright, whose limbs are sturdy and strong, and whose whole appearance tells of vigour and happiness. Healthy boys and girls love to run about, to laugh and to play; they are always ready for their meals, and they sleep sound all night long. They enjoy everything, work and play alike.

There are many unfortunate people who, though not really ill, are never in good health. Such people lose much of the happiness and joy of living. They find no pleasure in their work, and if any sudden need arises they are unable to meet it with a special effort. In the morning they get out of bed tired and languid instead of feeling refreshed and ready for the duties of the new day. They get through their work in a listless, indifferent way; they have little or no appetite for their food, and they sleep badly at night. Poor creatures! they lose much of the pleasure of life, a pleasure which most people might enjoy if they knew how to preserve and make the best of the health which they possess.

We must not imagine, however, that every person who is not strong and robust is therefore in such a sad case that he should sit down and lament his fate. Many a great work and many a valiant deed has been done by those who suffered from ill-health all their life long. General Wolfe, the hero of Quebec, carried through the siege and capture of that city with the greatest skill and courage, in spite of periods of severe illness. Lord Nelson, the idol of his country-

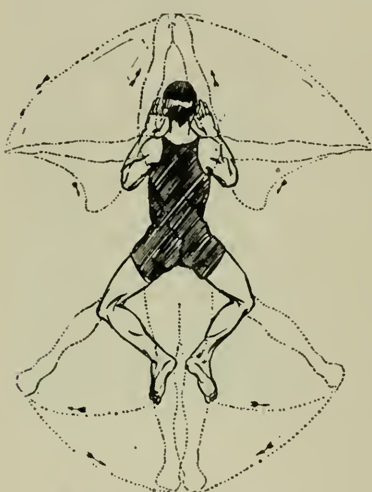
men while he lived and a hero for all time, did much of his life's work under the burden of illness. Cecil Rhodes, one of the greatest empire-builders of modern times, who did much to extend British power in South Africa, was sent out to that country at first because his health was not strong enough to stand the climate of England.

General Wolfe, the Hero of Quebec.

We cannot read the life-story of such men without admiring the courage and endurance that carried them through all their difficulties. Yet as we think of the great work which they accomplished, we wonder how much more they might have done, and how much pain and disappointment might have been saved them, if they had not been fighting against one of the worst of enemies—ill-health—in addition to all their other struggles.

For boys and girls, good health is doubly important. They should cultivate good health not only for the sake of the present but also for the sake of the future. If they are to become healthy men and women, they must take care to be healthy boys and girls, for it is while they are young that they must grow and lay up a store of health and strength for coming years. Health promotes health. Living a healthy life to-day is the only way in which we can provide for a healthy life to-morrow. A healthy and happy childhood prepares the way for a healthy and vigorous manhood or womanhood.

The care of our health does not require us to be always thinking about disease or sickness. It is only doctors and nurses who require to study diseases, in order that they may be able to cure or to prevent them. Other people, so long as they are in ordinary health, do not need to consider such matters. Indeed the habit of thinking about illness is one of the surest means of making one feeble and ill. The most unhappy people in the world are those who are always thinking about themselves and how ill they are and how unfortunate their lot is.



"*We must put our arms and legs in certain positions*" (*p.* 12).

At the same time there are certain things that must be done, and certain things that must be avoided, if we are to keep well, and surely it is wise for us to learn what these things are. The laws of health, as we call them, tell us what to do and what to shun in order to be healthy, and these laws are not hard to learn. Once we have learned them and have formed the habit of obeying them, we shall be living a healthy life without needing to give any thought to the matter. In all our games and exercises there are rules to be learned and to be practised, but once we have mastered these rules and are able to act in accordance

"Every one lived in the country" (p. 16).—["The Return of the Gleaners," a picture of French peasant life, by Jules Breton.]

with them, we think no more of the rules, but only of playing the game—unless, indeed, we should chance to break one of the rules, and then we must pay the penalty.

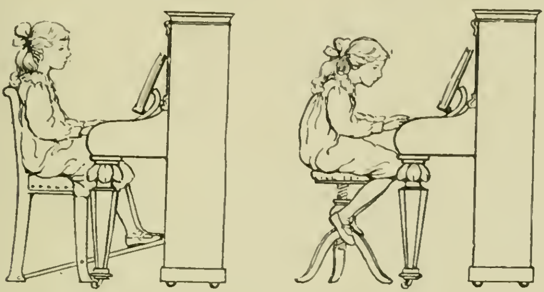
Let us take an illustration of what we have just said. Most boys and girls can swim or skate, or if they cannot do either of these things, they can at least walk and run. Now, in beginning any of these exercises, we must learn the necessary movements slowly and painfully, one by one. In swimming, we must put our arms and legs in certain positions and move them in a certain way. We rarely succeed at the first attempt, but careful practice makes the positions and movements easier, until at last we can swim a little. By-and-by we find that we can swim without thinking of our arms and legs at all. The rules have not only been learned, but they have become fixed in our brain and our muscles, and need no more attention from us.

"We must learn the necessary movements slowly."

The same thing happens with regard to health. If we learn the rules which we ought to obey, and form

the habit of doing the things which are good for health and of avoiding the things which would injure it, then, as in the case of swimming, after a time we keep to the good and avoid the bad quite naturally and without thinking about it at all.

Young people should know something about the structure of their body and the work that the various parts of it have to do. This is necessary in order that they may avoid injuring the body. A boy may get into the habit of sitting in a crooked position at his



"A girl may stoop instead of sitting upright at the piano."

desk, or a girl may stoop instead of sitting upright at the piano, and so may twist the backbone and injure it. Another boy may go on reading his favourite books while the light is bad, and may thus cause injury to his eyes. No one would do such things if he really knew what injury they would cause to his body.

But there is another reason why we should learn something about the structure of the body. The human body is the most wonderful thing in the world. It is more marvellous than any of the things we study in our nature lessons or our science lessons. There is nothing which can compare with the wonder of human

"A healthy and happy childhood" (p. 9).—["On the Sands," by Rosa Petherick.]

speech, the skill of the human hand, or the mystery of the human brain. It is by means of these that man has made himself master over the forces of nature. By means of speech or language he can hand on all that has been learned from one generation to another; by means of his hand he has made all the tools and instruments and machines that we have in our service to-day; and by means of the all-governing brain he uses all these for his chosen purposes.

If we wish to have our mind clear, acute, and well trained, we must train our body to be the willing and efficient servant of the mind. Many good people used to believe that we should cultivate the mind, but that the body was of little account and might be neglected and ill-treated. But we cannot afford to treat the body thus, for the mind is not independent of the body. If the body is ill-fed or overworked or out of order, the mind will not long remain clear and active. What the body needs is training, not neglect.

How is it possible to train the body? We have eyes, and ears, and muscles, and nerves, and brain, and many other organs in the body; how can we attend to the training of all these? It is not so hard as it might seem. The human body is very willing to be trained, and it has also a wonderful power of suiting itself to circumstances. We have just seen that when we learn to swim we use the same posture and the same movements time after time, and that by repetition the movements become easier and easier to perform, until we can do them without thinking. This is how the body is trained—by means of *habit*—and it is the law of habit that *repetition* makes any sort of action easy.

The law of habit applies to almost everything we

do. If we form the habit of going to bed at the same hour every night, our brain becomes ready and willing to sleep at that hour. If we remember a good many times to use a low, pleasant tone of voice when we speak, it becomes easier to speak in this way, and by-and-by our voices will keep to that tone always, whether we are thinking about it or not. If we work at one hard lesson after another until we master them, it becomes easier for us to face the next hard lesson, and one day we shall suddenly find that we have got to enjoy facing difficult problems and solving them.

The body has a wonderful power of suiting itself to circumstances. Some animals, such as the lion, are found only in hot countries, and others, such as the walrus, are found only in cold countries; man, however, is found all over the world, and can make his home in the frozen arctic and in the burning tropics. Man is much more adaptable than any other animal. The chief difficulty of arctic exploration has been, not to find men for an expedition, but to find animals for the transport work. Man can change his circumstances to suit his needs. He can alter his food supply and wear clothing of different degrees of weight and warmth, and he can thus adjust himself to very great changes of climate.

City life is a condition to which man has adapted himself. Long ago every one lived in the country. Now man has to face the problem of how to remain healthy under the conditions of city life. He has brought into the city a good water supply; he has arranged for the collection and destruction of refuse; he has laid out public parks as spaces for fresh air; he has instituted a system of health inspection and treatment of infectious diseases. A well-managed city is now actually a more healthy place to live in than the country, with

its often ill-ventilated cottages and its frequently poor water supply.

Besides being willing to be trained, and ready to adapt itself to new conditions, our body is provided with a set of danger signals to warn us when things go wrong and health is in danger. The most common of these danger-signals is *pain*. The pain of toothache tells us very clearly that a tooth is decaying and needs attention. The pain of a headache may tell us that we have been reading or writing too long, or that we have not enough fresh air in the room. Another common danger-signal is the feeling of *fatigue* or tiredness, which tells us that the body needs a rest or a change of work. The feeling of *hunger* is a danger-signal which we all understand: it warns us that nourishment is needed by the body. All these danger-signals are meant to guide us in treating our body so as to preserve it in health, and we are foolish indeed if we neglect them.

We are not to study disease in this book; we leave that very difficult subject to the doctors and others who are specially trained to deal with it. But we shall have to consider how we may best avoid certain common diseases. Many diseases come from without the body, and can be prevented, and we must learn how this is to be done. We must, above all, remember that there is one thing within the reach of every one which will be a great help in keeping us well, and that is the habit of *cheerfulness*.

> "A merry heart goes all the day,
> Your sad tires in a mile-a."

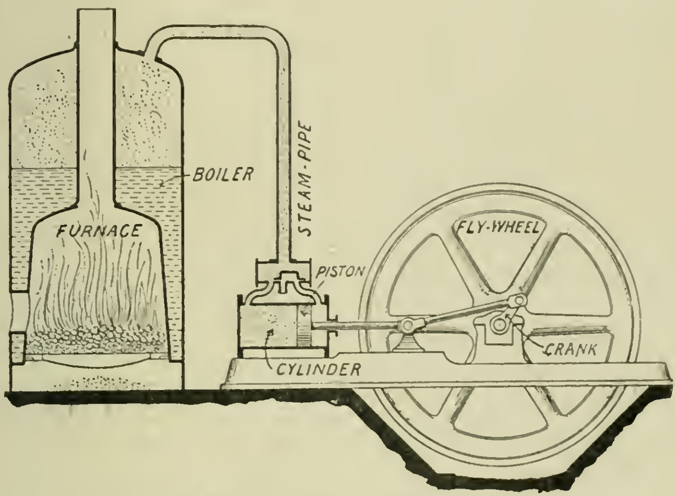
CHAPTER II

THE BODY AS AN ENGINE

All boys like to read about the boyhood of great men. They like to know what these men were like when they were young, and how they began to do the things which made them famous. The story of James Watt, the little Scottish boy who became the inventor of the steam-engine, is well worth reading. We are told that he would sometimes sit for a long time watching a kettle boil. Many boys had done this before him, but James Watt was not merely looking at the kettle; he was thinking about what he saw. He would hold a spoon in front of the spout, and see the escaping steam turn into drops of water on the cold spoon. When the kettle was nearly full, and the steam could not get out at the spout, he noticed that it pushed up the lid in order to escape, and the lid kept jumping up and down as the puffs of steam rushed out. So he learned what steam is, and how strong it is when shut up in a small space.

By-and-by James Watt became a scientific instrument maker, and one day he had to repair a small model engine which had been made to work by the power of steam. Several men had tried before this to make steam-engines, but none of these would work right. Watt studied this machine until he found out

what was wrong with it. At last he succeeded in making an engine that would really work, and he lived to see the steam-engine become the greatest power in the world. We can hardly imagine what the world would be like now if we had no steam-engines to draw our trains and drive our steamships, and to move all the machinery in our factories.



What a steam-engine consists of.

Let us see now what a steam-engine really is, and what it consists of. There is, first, the fire-box or furnace, where coal or other fuel is kept burning to supply heat. Next, there is the boiler to contain the water, which is to be turned into steam by the heat of the fuel. Thirdly, there is a cylinder with a piston moving inside it; the steam from the boiler passes through this cylinder, and pushes the piston backwards and forwards as it expands and forces its way out

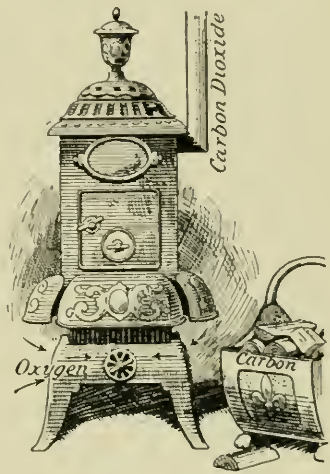
into the open air. And in the fourth place we have the crank and fly-wheel and all the other parts which are moved by the piston. In some engines of a newer type than that of James Watt there is no piston or crank, but the escaping steam turns a turbine or wheel shaped somewhat like a water-wheel. In any case it is the force of the expanding steam which moves the engine, and this force is due to the heat produced by the burning fuel. So the engine is really a contrivance for turning the energy of *heat* into *work* or movement. This is true of all heat engines, whether they work by steam or hot air or gas or oil.

If the engine is to work well, there must be plenty of heat produced in the furnace. We must provide the right kind of fuel, and a good supply of air to make it burn; we must provide a flue to carry off the smoke or waste gases from the fire, and we must remove the ashes and cinders, to prevent the furnace from being blocked up with refuse or waste materials. Some kinds of coal will not serve our purpose; there are great differences in the quantity of heat or of work which can be got out of different kinds of coal. Engineers are careful to use a good "steam" coal, especially on battleships and express trains, where great speed is required.

We must now try to understand what happens when coal or any other fuel is burned. The most important part of any fuel is a solid element called *carbon*. The air, as you know, consists of a mixture of invisible gases, and one of these is called oxygen. When carbon is heated in the presence of this gas, small particles or molecules of carbon unite with molecules of oxygen, and in doing so they become intensely hot. These then heat other particles, and

help them to unite with the oxygen also. So when we once start a fire, it will keep on burning as long as we provide carbon in the shape of fuel and oxygen in the supply of air.

When the carbon and oxygen unite, they form a gas called *carbon dioxide*, or carbonic acid gas. A little water is also produced by oxygen combining with a gas called hydrogen which is contained in the fuel, but the heat of the fire turns this into invisible vapour. The solid carbon has entirely disappeared. The oxygen has also disappeared, and the air which leaves the fire is quite different in its composition from what it was when it entered the furnace. We must, therefore, have a chimney to carry away the air that is charged with the carbon dioxide, and by means of the chimney a strong draught is created to draw plenty of oxygen into the furnace. At the same time the ash or waste parts of the fuel must be cleared away.



The carbon and oxygen unite.

Boys like to watch an engine at work. It seems very wonderful that a machine made of dead matter such as steel and brass should be able to move about or to do work. But the body is also a machine, built up of flesh and bones and other substances. When you think of it, surely it is no less wonderful that this

living machine should move about and do work. You are so accustomed to move about yourself that you may never have given this a thought. Every movement means the doing of a certain amount of work. The engine moves because it is driven by the steam. What is it that drives *you?*

Perhaps you say it is your *will;* you move when you wish to move. In one sense that is quite true. Your will is like the engine-driver, who decides when and how the engine shall move. Or you may say it is your *brain* and *nerves* that make you move; these send impulses of movement to all parts of the body. That is also true; they are like the levers and valves by which the engine-driver starts his engine. But in your body the actual work of moving is done by the *muscles*, the fleshy parts of the body and limbs. Where does the energy or power come from which enables the muscles to do this work?

Your muscles get their energy or power to do work from the food which you eat. The nourishment in the food is carried to every part of the body. It is this nourishment which builds up the body and makes it grow. It also repairs the waste which working produces in the muscles, and it supplies all the energy that the body needs. Your body, then, may be compared to an engine, and the food which you eat to the fuel.

The food which we eat—such as bread, meat, or eggs—does not look very like the coal or wood which we burn. But chemists tell us that things may differ much in appearance and yet be composed of the same elements. There is not much likeness between a sparkling diamond and the black lead of your pencil, and yet they are composed of the same kind of

"James Watt, the little Scottish boy" (p. 18).

[*From an engraving after Marcus Stone, R.A. By permission of Messrs. Henry Graves, Ltd.*]

matter. The most important element in fuel is carbon, and our chief articles of food are also largely composed of carbon. Sugar, fat, and the starch which is found in flour and potatoes, are all composed of carbon, combined in some way with two gases, hydrogen and oxygen. Our food, then, is very like fuel in its composition. And as some kinds of fuel are better than others for producing heat, so some kinds of food give more energy to the body than others, and are better suited for men whose muscles are doing very hard work.

In the engine furnace the fuel is *burned* to produce heat, a supply of oxygen being provided for this purpose. Let us see whether anything like this takes place in the body. When the food has been eaten and digested, the nourishing matter is carried to all parts of the body by the blood, and is built up into the various kinds of tissue which are needed, such as flesh and bone. But the blood also receives oxygen from the air in the lungs, and this oxygen is carried by it to all the tissues of the body. When the oxygen is brought into contact with these tissues, they do not flare up and burn as coal does, but none the less they change in much the same way. They undergo a slow change which corresponds in many respects to combustion or burning.

During this change, waste materials are produced of the same kind as in the engine furnace. The chief of these are water and carbon dioxide. Some of the water passes out through the pores of the skin as perspiration. Some of it is breathed out from the lungs, as you can see in cold weather by the little clouds of vapour which the breath carries with it. The carbon dioxide is also carried by the blood to the

lungs, and is thus removed from the body by the breath.

Like the engine, the body does not work well if we give it too much or too little fuel, or if the fuel is not of the right kind. And just as there must be a good draught in the furnace to supply plenty of oxygen, so the body needs abundance of fresh air for the same purpose.

Sometimes we put too much fuel into the furnace of our body, and it becomes choked with waste matter. Then it cannot do its work, and we say that we feel ill, or have no appetite for our food. We may require medicine to help the body to get rid of the waste matter, or a little more exercise and fresh air, with lighter food, may put it right again. It needs a good deal of care to stoke a furnace properly, so as to keep up a high pressure of steam in the boiler; and these engines of ours also need careful stoking to produce the full amount of energy for our work.

Our body is a much more wonderful and perfect machine than a steam-engine in many ways. The steam-engine needs a great deal of heat in the boiler, and in order to get this the furnace must be kept extremely hot; much of its heat is wasted, however, and does not go into the boiler at all, while a great deal of the heat of the steam is also wasted as it blows off into the air. In the body, however, the heat is produced in all parts of it, and is just enough to keep us comfortably warm when our muscles are doing their ordinary work.

A still more wonderful thing about the body is that it uses the fuel we give it to build up the engine and keep it in repair. And this building and repairing of the engine are best done while the engine is actually

working. A steam-engine must be completely finished before it can begin working, and when any part wears out or gets damaged the engine must be stopped until a new part is fitted into it. But the young child's body builds itself up and makes itself strong all the time that it is actively working—and a young child, as you know, does not let its muscles rest long. The fuel which keeps the little engine running is at the same time repairing all the waste which the work produces, and is also making every part of the engine bigger and stronger day by day. No machine invented by man can do that. Man cannot put *life* into a machine; and it is that mysterious thing we call life which makes our body infinitely finer and more wonderful than any engine made out of dead matter.

CHAPTER III

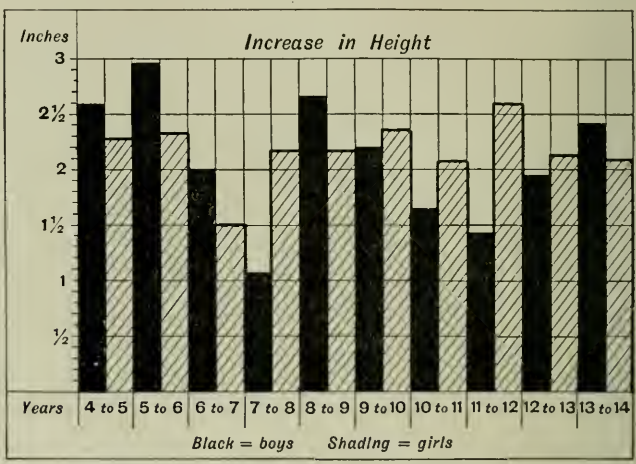
GROWTH

"When I am a man," said a little boy, "it will feel awfully funny for the first day or two!" He had just begun to realize that little boys do grow up to be men, but he did not think that they grow so very slowly and gradually as they do. Growing up is not a matter of a day or two; it needs some twenty years or more. All healthy young creatures grow, some faster and some slower, until they reach their full size. The lower animals grow much more quickly than boys and girls do. The growth of a lamb into a sheep, or of a kitten into a cat, only requires a few months; a boy or a girl takes many years to grow into a man or a woman.

There is a good reason for this. Growing means more than getting bigger and heavier; it also means that the body is becoming stronger, and able to do better the things which we require to do in after life. While growing we are also learning. Brain and nerves and muscles become bigger and heavier and stronger, but this would be of little use unless they also became better servants of the mind and will. So children grow more slowly, and have a longer time of youth than the lower animals, because they must have more time to learn. They need to learn

many habits and to practise many kinds of work, and the body builds itself up slowly so that we may have the opportunity of building it in the best way.

Children grow most rapidly in their infancy. A child has reached half its full height when it is two years old. All persons do not grow to the same height. Even in one family, some may be short and others tall, while there are often great

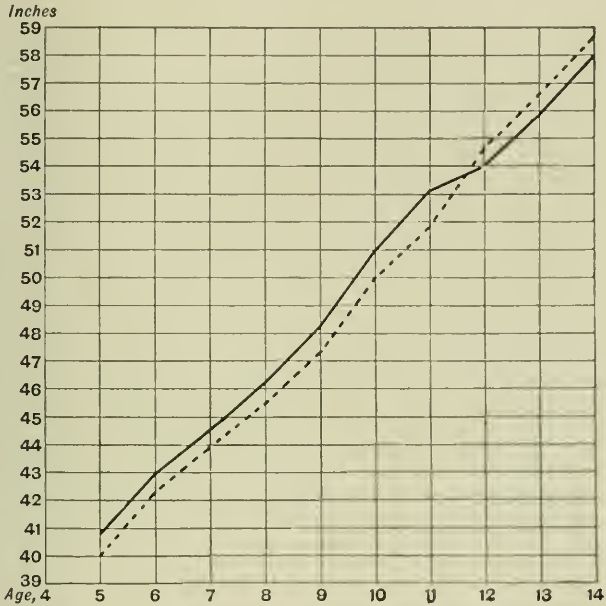


This diagram shows how much we grow every year.

differences in the average height of different families and of different races of men. But while height depends a good deal upon the race and the family to which one belongs, the strength of the body and of its various parts depends chiefly upon its proper nourishment while it is growing.

When the body grows in size, it actually contains more tissue than it did before—a greater quantity of muscle, bone, skin, and all the rest. Your bones

are longer and thicker and heavier than they were when you were a child of seven, and every part of your body contains more material. Where did the new material come from? It has all been supplied by the food which you have eaten. Your food has not only given you heat and supplied you with



This diagram shows the average height of boys (——) and girls (– – – –).

energy for all the work which your body has done, but it has actually added new material to all the different organs and tissues which the body contains. No wonder that you have been hungry at meal times, and even before meal times! Your growing body was calling out not only for fuel but also for building material.

You have been told that foods containing carbon give out energy and heat; and carbon is also needed to build up some of the tissues of the body. But these tissues also require a substance called nitrogen. The greater part of the air is composed of pure nitrogen, but the body cannot make use of this; it must have foods containing compounds of nitrogen and other elements to build up its tissues. Hence, if we are to grow and to be strong, our meals must give us various kinds of food containing both carbon and nitrogen. The food must also be plain and wholesome, so that the body may be able to get from it the nourishment which it contains. Milk is the best food for children, as it contains all the substances that are needed for growth and for energy and heat. Oatmeal contains good material for growth. So oatmeal porridge and milk is an excellent meal for children. But it is so important to know what foods are good for us that this subject must have a chapter to itself.

Our growth and strength depend upon the *quantity* of food we eat as well as the kind. Doctors and other learned men have made careful studies of how much food is required, and we shall learn something about that later. But even if you knew exactly how many ounces of carbon and other materials were needed by your body in a day, that would not help you much in knowing how much bread or meat you ought to eat at any of your meals. You have a much better guide to follow, and that is your *appetite*, or hunger. If the food is plain and wholesome, you will not go far wrong if you eat as much as your appetite makes you wish to do. The feeling of hunger is just the call of the body for

nourishment, and when the body has had all it needs our hunger ceases.

This does not mean, of course, that we are to eat all we can. Sometimes children are very fond of certain foods, especially sweet dishes, and if they were allowed to do so they would go on eating of these until the furnace of the body was quite

These two young rats are of the same litter. The upper one (a) has been fed on bread and milk, and the lower one (b) on beefsteak. Note the difference in growth.

choked up with waste materials, and could no longer do its work. Such foods are very pleasant when they are used aright, but if we had nothing else to eat we should soon tire of them and wish for plainer food. We never tire of plain food. It is from this that the body gets most nourishment, and it is this that our appetite demands when we are hungry. When we have eaten as much as the

body needs, we have no desire to eat more for the mere pleasure of its taste.

If children have not enough food they do not thrive. Their growth is slow, and they are not tall enough or heavy enough for their age. They are thin and pale, for their blood is wanting in nourishment, and cannot build up the reserve store of fat under the skin which makes one look plump and healthy. They have little energy and are easily tired, whether they are doing school lessons or other work. We often see in our city streets children who are like that.

We must not think, however, that all such children suffer from hunger and cannot get enough to eat. In many cases they are badly nourished because their parents do not give them the right kind of food. Perhaps the food which they eat costs more money than more nourishing and plain food would do, but their bodies are starved in spite of the money spent on their food. Rich and highly-flavoured dishes spoil the appetite and the digestion, and the body is left without sufficient nourishment. Tea and fine white bread are too often given in place of cheaper but more nourishing foods.

But it is also true that many children, and grown-up people as well, suffer because they cannot obtain a sufficient quantity of food. Then the fat stored in the body gradually wastes away, the muscles are not repaired with new material, and they become thinner and weaker day by day, and if this is allowed to go on the person dies of starvation. In some lands famine comes from time to time through failure of the crops. This often happens in India, and the Government spends great sums of money in

"*We never tire of plain food*" (p. 31).—[*The Frugal Meal, a Dutch picture, by Josef Israels.*]

bringing food to the districts where the people are suffering from famine. Sometimes a great strike of workmen leads to want in their homes, and the little children suffer more from hunger than the older people. In time of war, when a city is besieged by the enemy, it cannot hold out after the food is exhausted. Hunger is the most terrible foe of all. We are so much accustomed to plenty of food that we hardly realize how necessary food is.

There are many ill-grown and starved-looking children in our cities who do not suffer in any way from want of food. Growth depends a good deal upon other things. *Exercise* and *fresh air* are as necessary as food. The muscles of a blacksmith's arm are much bigger and stronger than those of a clerk, and this is due to the exercise or work which is done by these muscles. Work causes waste, and the blood hurries to the working part with stores of new material to repair the waste, and not only to repair it but to build up extra tissue for future use. If you were to tie up one arm and never move it, it would soon become thin and weak and useless. It would not grow so well as the other arm. Fresh air, as you have been told, is required to give oxygen to the blood, and without oxygen the furnace of the body cannot work properly. Both for exercise and for fresh air a country life is better than a city life; but if we remember that these things are necessary to make us strong, we can easily find opportunities for getting enough of them even in our cities.

There is another reason why city children sometimes look pale and tired in school, and are not so big as country children of the same age. They do

not get enough *sleep*. Sleep is the time when the body seems to do most of its growing and repairing, and children need a great deal more sleep than grown-up people. A baby sleeps nearly all the time except when it is taking food. Young children need a long sleep at night and a sleep in the afternoon as well. Boys and girls at school require from ten to twelve hours' sleep, and should never have less than ten until they are over fifteen years old.

Now in our cities there are many things that rob children of their necessary sleep. Their parents may keep late hours, on account of the nature of the fathers' work. The children often have evening parties and entertainments which encroach upon the time for sleep, and thus do more harm than good. Irregular hours may be kept, and when the children might go to bed at the right time they do not feel sleepy, because they have not formed the habit of going to sleep at a fixed hour each night. Late noises in the house or in the street often disturb the children's sleep, even when they are not actually wakened, and it is sound sleep which they need. There are many causes of this kind which rob city children of their sleep, and make them grow up pale, sickly, and nervous, instead of rosy, active, and sturdy as every child ought to be.

There is one other thing that affects the growth of children, and that is *clothing*. The chief use of clothing in our country is to keep us warm. As we have said, our body makes its own supply of heat. It is a slow-combustion furnace, where the oxygen of the air and the carbon of the food are always uniting to form carbon dioxide, and in so doing they produce the heat which the body requires.

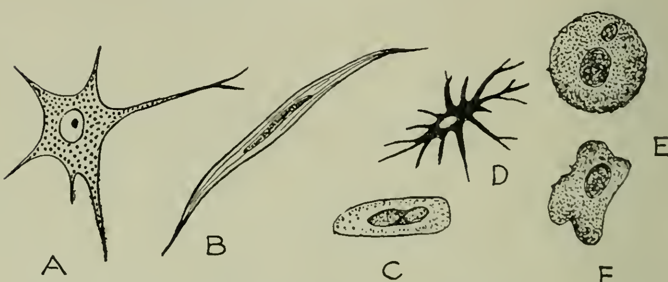
"Hunger is the most terrible foe" (p. 32).—[*Edward the Third distributing food at the Siege of Calais, by Sir John Gilbert, R.A. By permission of the Corporation of London.*]

If our clothing is too light, or is of an unsuitable kind, the surface of the body gets chilled by the cold air. Its heat is wasted, and the furnace must work to produce more heat. In this way the carbon of our food is wasted, and there is less of it available for growing and other purposes. A farmer knows that if his young calves or lambs are to grow well, they must be sheltered from the cold. If they are not, they will need more food, and even then they will not be plump and well-grown and healthy-looking. It is the same with children: insufficient clothing causes a waste of the heat of the body and checks its proper growth.

Now we must see how the growing and the repairing of our bodies are actually carried on. When any part of a steam-engine becomes worn it must be taken away and a new part put in its place. The parts of the body do not wear out in this way. They go on repairing themselves all the time they are working. That is one of the great differences between living and dead matter. Living matter is always changing, and changing in such a way as to benefit the individual body of which it forms a part. The whole body is composed of cells—tiny bags of matter of various sorts—and while each cell seems to live a little life of its own, it also acts along with the other cells in preserving the life of the body.

Perhaps you have seen men building a wall at the side of a river. Now imagine that the wall is to be built of bags of cement: the cement is soft at first, and as the bags are put into their places they fit together quite easily and then become hard. But now you must imagine something very

wonderful. The bags come floating down the stream of their own accord, and slip into their places without any one touching them. Besides, when any bag gets damaged the river carries it away and a new one comes floating along and slips into the place of the old one. The wall builds itself and also keeps itself in repair. But however much we may strain our imagination and fancy all kinds of wonderful things, we can never picture to ourselves all the wonder that there is in our living bodies.



Some of the cells which build up the body. (A, brain cell ; B, muscle cell ; C, D, bone cells ; E, F, blood cells.)

The cells which build up the body have different work to do, and require different materials, and each of them takes from the blood just the kind of material which it needs. We have brain cells, which in some way supply the energy for our thinking and for guiding the movements of our muscles. We have muscle cells, which can contract so as to become shorter and thicker for a time, and which thus cause all the movements of the body. We have bone cells, which fill themselves with hard matter just like the cement bags of which we spoke. We have various kinds of blood cells, some of which carry oxygen

from the lungs, and some of which behave like those tiny living creatures which we call microbes or germs, and attack any disease germs which may get into the blood; we shall have more to say about these strange little cells in other chapters. Each cell has some work to do, or some material to take out of the blood and build up into its own special kind of tissue, and in this way the whole body grows to its full size and is kept in repair all through life. Truly the Psalmist was right when he said that we are "fearfully and wonderfully made."

CHAPTER IV

THE BUILD OF THE BODY—I

If you were asked to describe your body as you might describe a flower, or a machine, or some other object, how would you set about it? You might begin by naming the chief parts of which it is made up: these are the head, the body or trunk, the two arms, and the two legs. You might also mention that in the framework of the body there are hard parts called bones, which support it and keep it in shape, and soft parts called flesh or muscles, which move the body, and that over all is a covering called the skin.

When a baby is quite young it cannot stand upright or walk, although it has bones and muscles. That is because the muscles are still weak, and the baby has not learned how to use them so as to keep its balance. Besides this its bones are still soft, and the weight of the body would cause them to bend and put them out of shape.

Bone consists of two substances. The one is somewhat soft and yielding, like what we call "gristle" in meat. This is the living, growing element in bone, for the bones must grow as the rest of the body grows. The other material is a hard mineral substance chiefly composed of lime, and this material is gradually mixed with the other, making the bones stiff and hard. Some

"*When a baby is quite young*" (p. 40).—["*First Steps,*" *by F. J. Millet.*]

animals have the power of laying down lime on the outside of their body. It forms a hard shell, which protects the softer parts of the body. We see examples of this in the lobster and other "shell-fish," as we call them. In the human body the lime is deposited in the soft material of the bones.

A baby's bones are soft because they contain very little lime at first. That is why very young children should not be encouraged to stand up. Until they are nine months old or even older, the bones are not strong enough to support the weight of the body, and they easily become bent. When children get food which does not contain enough lime, their bones do not harden properly; they may be put out of shape by the weight of the body, and remain bent throughout life. Milk contains lime, and this is one reason why milk is a good food for young children.

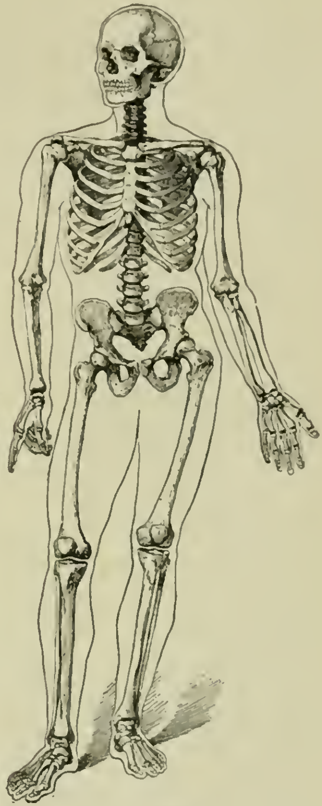
It is not babies only who may have their bones bent and put out of shape. The bones of older children are also softer than those of grown-up people, and we shall see that there are several ways in which even big boys and girls may put their bones into bad positions. The bones do not stop growing until we have reached our full height.

The large bones are not solid throughout. There is a hollow part in the centre, which prevents the bone being too heavy. This hollow usually contains a fatty substance called marrow, but the hollow bones of a bird contain air only, as they must be as light as possible for flying.

The framework of bones which lies within the body is called the *skeleton*. If we look at a picture of the skeleton, we see that it consists of a very large number of bones; we should never have supposed that there are

so many. The number of bones in the body is no less than two hundred and six. They differ greatly in size and also in shape, some being long and round, others broad and flat, and others irregular in form.

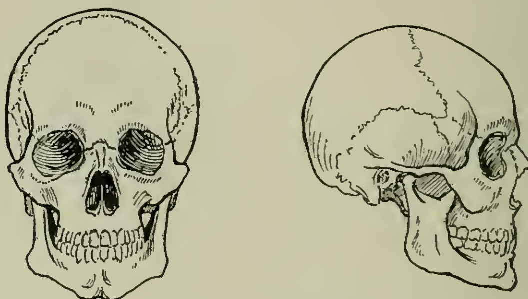
Like the body of which it is the framework, the skeleton divides naturally into the head, the trunk or body, and the four limbs. In the trunk, however, we see a considerable difference between the bones of the upper part, or chest, and the lower part or abdomen. The chest has bones all round it, while the abdomen has bones only below and behind it.


The Skeleton.

Let us look now at the various parts of the skeleton in turn, beginning with the head. When a man has a large sum of money in the house, or valuable papers, he usually keeps them in a "strong-box" or safe. The bones of the head form a strong-box, in which something of the greatest importance is kept—that is, the brain. The brain, as we shall see later, is that part of the body which governs every other part, and the well-being of the whole body depends upon it. The

brain is composed of soft and delicate matter and is easily injured, and so it must be protected from harm.

The strong-box of bone which contains the brain is called the skull. It is made up of several flat bones, joined together very firmly by toothed edges. The skull is very strong—strong enough indeed to resist any ordinary injury. It is a very bad fall or a very severe blow that can break or fracture the skull. In young children, however, the bones of the skull are very soft, and as the brain then grows rapidly the bones also grow



The skull, front view and side view.

at the edges so as to make the box larger year by year.

You may have heard of a tribe of Indians in the west of Canada called Flatheads. They used to bandage the heads of their children while the bones were soft, so as to make their heads much longer, and as the bones hardened they kept this curious form, flattened on the forehead and projecting upwards at the crown. It was a very absurd custom, but we are sometimes guilty of conduct quite as foolish, when we treat our soft growing bones so as to put them out of shape.

If you look at a drawing of the skull, you will notice

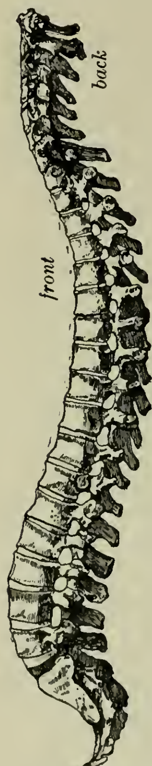
how the bones of the face are arranged. The upper part is the forehead, which is much higher in some people than in others. It used to be thought that people with a high forehead had a better brain or were cleverer than others. This is not the case, however, and many clever people have a low forehead. Below this you see two deep cavities called the orbits or eye-sockets, which contain the eyes. These delicate organs are protected by bones all round except in front.

Below these, and in the middle line, you see another cavity, which is that of the nose. In the skeleton the nose seems very short. That is because the lower part of the nose has its framework not of bone but of a softer substance which we call cartilage, or gristle. Within the nose cavity there are thin curved bones, over which the soft lining membrane of the nose is folded so as to give it a larger surface than if the walls of the cavity were smooth or plain.

Still lower comes the large cavity of the mouth, with the teeth in the upper and lower jaws. The teeth themselves are not bones, however, as you will learn in a later lesson. The lower jaw is the only bone of the head which has joints that can be moved. It can move up and down, and also slightly from side to side. It is this movement of the lower jaw which enables us to chew our food, and also to produce many of the sounds of speech.

Notice also the small opening on the side of the skull. This is the entrance to the ear passage. The ear itself—not the projecting part which we see, but the part which is actually concerned in hearing—is placed quite inside the bone. Like the brain and the eye, it is an extremely delicate structure, and so, like them, it is well protected by bone. With so many

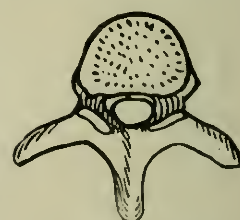
delicate and important organs contained in it, you can understand why no one should ever strike a blow at the head, and especially at the ear, not even in fun. The ear may easily be injured even by a slight blow.



A side view of the spinal column.

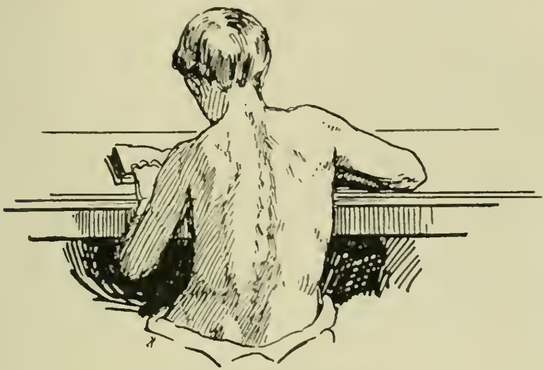
There is one opening in the skull yet to be noticed, and that is in the lower part or base of the strong-box. Through this opening a thick cable of nerve tissue called the spinal cord passes from the brain down along the backbone, from which nerves branch off to all parts of the body and the limbs. The base of the skull rests upon the backbone or spinal column, and this we must next examine.

The backbone is the chief support of the body, both of the chest and the abdomen. It is a column built up of thirty-three separate bones. When we look at one of these bones we see passing through it the canal in which the spinal cord lies. In front of this is a solid block which forms the body or chief part of the bone. The body of each bone rests firmly upon that of the one below, with a pad of cartilage between them. This pad keeps the column of bone from being jarred as we walk or jump. Behind the canal there are projecting parts which fit into the


A bone of the spinal column.

bones above and below, and the whole is bound together by a tough, fibrous material, so that the bones cannot slip out of their place in the column.

When we look at a side view of the spinal column we may be surprised to find that it is not straight. It has several curves. It curves slightly forward in the neck, backward in the region of the chest, forward again in the abdomen, and then backward. In a very young child these curves are not present. They begin



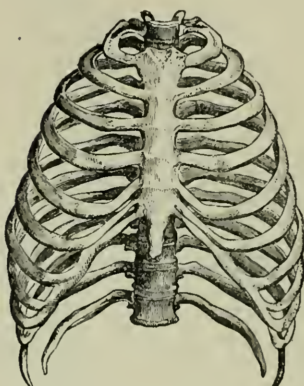
"*Crooked and ungainly.*"

to appear as the muscles of the back develop, and as the baby learns to hold up his head and to raise himself and balance his body.

We mentioned that growing boys and girls sometimes act so as to bend their unhardened bones and put them out of shape. The spine often gets bent in growing children. When you stand on one foot, or sit sideways at your desk, holding one shoulder higher than the other, you are bending your spine into a bad position. This not only makes you look crooked and ungainly, but cramps the ribs on one side and interferes with the

free movements of the chest in breathing. Habits of sitting and standing so as to bend the spine are quite as foolish as the Indian habit of bending the bones of the skull when their children are young. The Indians might excuse themselves by saying that the flattened skull improves their appearance, but we cannot say this about a bent or crooked backbone.

The upper part of the body is called the chest or thorax. Here the bones form a cage-like structure within which are the heart and the lungs. This cage is formed by the ribs, of which there are twelve on either side. The ribs curve round from the backbone to the flat breast-bone in front, to which the upper ribs have their front ends joined.

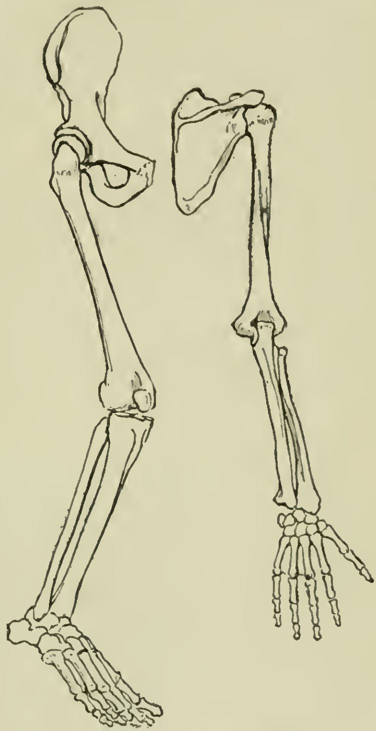


The chest or thorax.

The chest differs from the other bony cavities of the body in being able to expand and contract. It can increase in size in order to allow the lungs to be filled with air. You can feel the ribs rise and fall as you breathe in and out. If the chest does not move freely, the lungs cannot expand and take in a full supply of fresh air; then the blood is not rightly purified, and the health suffers. Since the chest is meant to move in this way, you can see how foolish it is to wear clothing which cramps and restrains its movements.

But wearing tight clothing is not the only way in which we sometimes hinder the free movement of the chest. As you have just read, we may do the same

kind of injury by stooping or bending sideways at our work, or by allowing the shoulders to become rounded or the chest flattened and hollow. If we are to have a well-developed chest we must keep the back erect, the shoulders thrown well back, and the lower part of the chest expanded. Not only does this improve one's appearance, but it also promotes good health, as we shall see later when we consider the action of the lungs.

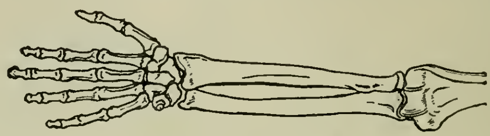


Bones of the leg and the arm.

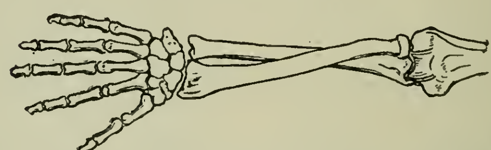
The chest is separated from the lower part of the body, or abdomen, by a thin sheet or membrane formed chiefly of muscle. This muscle is the floor of the chest, as we may say, and the roof of the abdomen. The abdomen has the backbone behind, and is supported in front by strong fibrous membranes and muscles. Below, it is supported by two large, irregularly-shaped bones which form a basin-shaped hollow known as the pelvis. The largest organs in the abdomen are the stomach and the intestines, the liver, and the kidneys.

When we look at the bones of the limbs, we see that

those of the arm and the leg are very much alike in their arrangement. The upper bone of the leg is jointed to the pelvis; that of the arm to what we call the shoulder girdle. The shoulder girdle consists of two pairs of bones—the broad, flat shoulder blades behind, and in front, running from the neck to the top of the shoulder, the long, slender collar bones, which frequently get broken in rough games. The shoulder



Right hand, palm upwards.



The same, palm downwards. Note how the bones of the forearm cross each other.

joint has much more freedom of movement than the hip joint.

In the upper part of the arm, and also of the leg, there is a single strong bone with a long, round, hollow shaft. The next part of each limb contains two bones lying side by side: in the arm these occupy the space between the elbow and the wrist, and in the leg between the knee and the ankle. In this part also the arm has more freedom of movement than the leg. Lay your arm flat on the table with the palm of the hand upwards. Then, keeping the elbow still on the table, turn your hand palm downwards. You cannot move your leg and foot in this way.

In the wrist and in the ankle there are a number of small bones firmly bound together, and then come the long jointed bones which form the body of the hand and the fingers, corresponding to those of the foot and the toes. The hand, however, has a much freer range of movement than the foot. You can make the thumb and the little finger meet across the palm of the hand, but you cannot move the great toe and the little toe in this way.

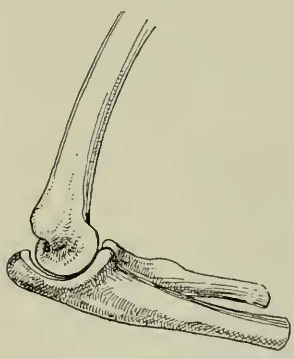
The general difference between the upper and the lower limb is that the leg and foot have developed solidity and strength, by having to support the weight of the body and doing nothing else. The arm and the hand have acquired much greater freedom, and can perform very fine and accurate movements. The hand can be trained to carry out the highest ideas of the mind, and on this account it is one-of the most wonderful organs of the body.

Photograph of the hand taken by the X-rays. The bones show dark through the flesh of the hand.

CHAPTER V

THE BUILD OF THE BODY—II

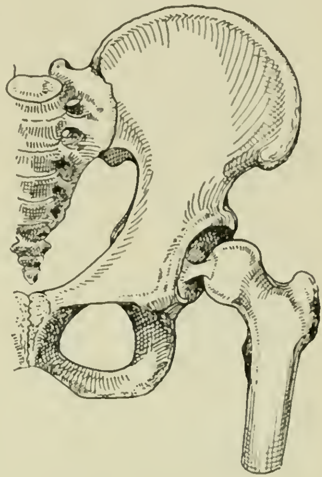
We have seen what bones are like and how they are arranged to form the skeleton. Let us now see how they are bound together or jointed into one framework. A *joint*, as you know, is the meeting-place of two or more bones. There are many joints in the body, and these differ greatly in appearance. When we come to examine them, however, we find that they may all be divided into two classes — joints which allow of movement between the bones where they meet, and joints which do not. Those where movement is possible are known as *perfect* joints.



A hinge joint—the elbow joint.

Hold your upper arm rigid and move the forearm at the elbow joint; you can move it a certain distance in two directions, backward and forward. The joint acts like a hinge, and is therefore called a *hinge* joint. Now, hold the forearm rigid and move your hand at the wrist. The small bones of the wrist slide a little way on one another, and so the hand can be bent

backwards and forwards, and also from side to side. Swing your arm from the shoulder, and you will find that it can move freely in a circle in any direction. The shoulder joint is called a *ball-and-socket* joint, because there is a round knob or ball at the top of the bone of the upper arm which fits into a cup-shaped hollow or socket in the point of the shoulder blade. The hip-joint is also a ball-and-socket joint. All these are perfect joints.



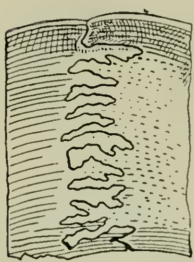
A ball-and-socket joint—the hip joint.

You have seen the bones in beef or mutton, or in the leg or wing of a fowl. Where there is a joint, the end of the bone, especially before it is cooked, is very smooth and has a white glistening appearance. This is due to a covering of cartilage on the end of the bones which enables them to move more smoothly upon one another. The ends are also shaped so as to fit exactly together, and to aid still further in smoothness of movement, there is a covering round each joint which secretes a kind of oil, just as we put a drop of oil on a metal hinge to make it move easily and without creaking.

But while smooth movement is necessary, it is also necessary that a joint should not move too far, or in any direction other than is required by the body. This is partly prevented by the strong fibrous covering or capsule which surrounds each joint. In some

joints there are projecting parts of the bones which meet and prevent the joint from moving too far. Thus when your arm is bent you can move it at the elbow until it is straight, but it will not go farther. There is a bony projection behind the elbow which prevents further movement. The muscles are also arranged so as to allow only the necessary degree of movement in a joint.

We are not likely to take so much interest in the *imperfect* joints in our body, where bones meet in such a way that there is no movement between them. Some of these joints have been already mentioned—the joints found in the skull, where the bones are firmly fixed together by their toothed edges. Sometimes the joints are so close that one might look at the bones without seeing the joining.

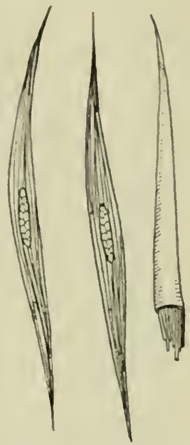


The bones of the skull, joined by toothed edges.

The joints are protected by the membrane which surrounds them and by the muscles, but they sometimes get injured by having the bones pulled out of their place. This is called a *dislocation;* we often speak of it as some part being "put out of joint." When this happens the bones must be put back into their place again. Young children sometimes have their joints injured in a way which few people seem to think of. One often sees careless people pulling children roughly about, or perhaps even lifting a child off a street car by the arm. This is really very dangerous, as a joint may be injured, or even a part of a bone may be pulled out of its place. We should remember that children's bones are not so hard as those of older people.

We must now consider the other structures which

form the support of our bodies—namely, the *muscles*. Probably you have never seen a person faint, but you know that when a person who is in delicate health becomes very tired and exhausted he sometimes becomes unconscious and suddenly falls down. Why should he fall instead of remaining upright? It is because the muscles suddenly relax. The body is held in an upright position by the muscles keeping up a certain steady tension, those on the front of the body and the legs pulling against those of the back, so as to balance the weight on the feet. The muscles do a considerable amount of work in merely holding the body upright, and this is why you feel tired after standing at "attention" for a while. The muscles also cause all the movements that are made in the body, and so they have a great deal of work to do. We need a large quantity of muscular tissue to do all this work, and the weight of the muscles is more than one-third of the whole weight of the body.



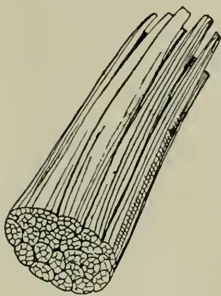
Spindle-shaped muscle fibres from the internal organs (sheath removed from two of the fibres).

Muscle fibres from the skeletal muscles.

The muscles are of two kinds. One kind is found in the walls of the hollow organs of the body, such as the stomach and the blood-vessels. This kind of muscle is built up of fibres, each of which is shaped like a spindle—thick in the middle and thin at the ends. The other kind of muscle is

found in the large bundles of fibres which are connected with the bones, and form the "flesh" of the body.

By far the greater part of the muscular tissue of the body is connected with the skeleton. The beauty of form and attitude of the human body depends upon the proper development of the muscles. The people of ancient Greece had a deep love for beauty, and in order to develop their bodies in the best way they gave great attention to athletic exercises and games. The well-known statue of the man throwing the discus or quoit is a fine example of the beauty of a Greek athlete. When certain muscles are over-developed by constant use they become very hard and strong, and stand out in irregular masses. You all know Longfellow's description in the "Village Blacksmith,"—



Bundle of fibres forming a muscle.

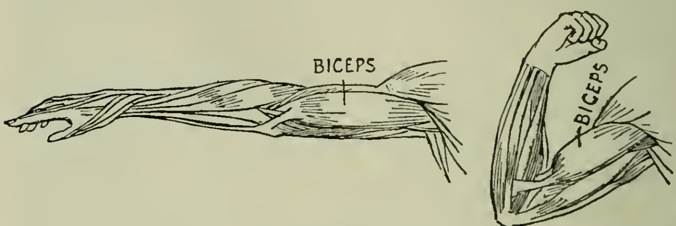
"The smith, a mighty man is he,
With large and sinewy hands;
And the muscles of his brawny arms
Are strong as iron bands."

A muscle is a thick mass of fleshy fibres attached to a bone at each end, either directly or by means of a band of hard, tough fibres. The bands which join the muscles to the bones are called *tendons*. Several of these pass down the wrist, and a very large one can be felt at the back of the heel. This is called the "tendon of Achilles," from an old Greek story. When the hero Achilles was a baby, he was dipped by his mother in a magic fountain which had the power of preserving his body from all wounds. In doing this,

"*The well-known statue of the man throwing the discus or quoit is a fine example of the beauty of a Greek athlete*" (p. 56).

however, the mother held the baby by the heel, and it was on this part of his body, which had not been wet by the water, that he received his death-wound.

The muscles connected with the skeleton, or *skeletal* muscles as they are called, are made up of parallel bundles of striped fibres. When a muscle contracts each of these fibres becomes shorter and thicker, and so the whole muscle shortens and thickens, and draws closer together the two bones to which its ends are attached. Grasp with your left hand the fleshy mass which lies on the front of your right arm between the elbow and the shoulder. Now bend your right elbow, bring-



The contraction of the biceps muscle.

ing the right hand up as near the shoulder as you can. You do this by the contraction of the biceps muscle on which your left hand is resting, and you can feel it becoming thicker and harder as the movement is made.

The muscles rarely act singly. What may appear to be a simple movement due to only one muscle is often caused by the contraction of several. When you nod your head, or shake it, a number of muscles are acting. When you dance you employ groups of muscles in both legs, and also many in the body. When we perform any series of muscular movements smoothly, our muscles are said to *co-ordinate*—that is, to work together. Some actions can be carried out easily and smoothly from

the beginning of life. Breathing is a complex process, requiring the action of many muscles, and yet breathing is carried on as well on the first day of our life as it is afterwards. The same is true of the beating of the heart and of many other movements.

There are movements, however, which are less easy to perform. A baby can very soon move the bigger muscles of his limbs, as you can see by his kicking, and tossing his arms about. He is several years old, however, before he learns to control the smaller muscles which move the hand and the fingers. Many of the things we learn in school are exercises for the smaller muscles. Writing and sewing are done mainly by the muscles of the hand; reading requires the movement of the finer muscles of the eye, and so on. All these have to be gradually learned.

If we had to learn by memory all these movements, and to think out what was wanted at every step, we might give up the task in despair. But, fortunately, the muscles themselves seem to remember it all for us—or rather the nerve cells, which, as we shall see later, control the muscles and make them act when required. So when we have learned and practised such complex movements as those of sewing or dancing, the muscles and nerves take charge of the matter for us, and all we need do is to make up our mind to begin. When we have learned to walk, we no longer need to study how to place our feet at every step; and when we practise a piece of music on the piano or the violin, our fingers seem to find their way about without our giving any heed to them.

This is of great advantage to our health, for we can train our bodies to the postures and movements which are good for health, and then the matter needs no

more attention. You may have heard the old Scotch proverb,—

"Learn young, learn fair;
Learn auld, learn sair."

This is true of what the muscles learn as well as the mind. The time to train the muscles is while one is young. Young people not only learn to swim or cycle or dance more quickly and more easily than older people, but they also learn to perform the movements better and more gracefully.

You can see now that the muscles have a more important work to do in the body than you had perhaps been aware of, since they carry on all the movements not only of the limbs but also of the internal organs on which life and health depend. It is in them also that the heat of the body is largely produced, and it is by means of certain muscles we exercise the wonderful power of speech.

There are small groups of muscles in the skin which are of much interest. Some of them are connected with the roots of the hairs; these are of little importance to us, but by means of them certain animals have the power of making their hair stand upright, as you may see a cat or a dog do when angry. The muscles in the skin of the face, however, are of more importance. They are sometimes called "muscles of expression," because it is by their action that the face takes on the expression of a smile or a frown, and looks pleased or angry or pained. When these muscles contract, they cause certain folds or lines or wrinkles to appear in the face.

Now the muscles of expression are like other muscles in this, that if they do the same thing again and again, they are able to do it all the more easily. The lines

and wrinkles which in early life disappear as soon as the smile or the frown has passed, by-and-by become more marked and even permanent. That is how the faces of older people get lined in various ways. The muscles have been so often used in a particular way that the expression which they produce remains on the face. You may have heard of reading one's character from his hand. A far truer and easier way is to read it from his face. By the time one reaches middle age, his face shows whether he is kindly or harsh or fretful. It does not matter much what our face looks like when we are young, but soon our character begins to be written upon it. Those tiny muscles of the skin move in accordance with our mood, and write its expression upon our face as plain as if the word "cross" or "selfish" or "cheerful" were to appear there. We have those muscles under our control at first, and can easily choose the better and dismiss the worse. Soon, however, both our moods and our muscles obey the great law of habit, and the lines upon our face become the record of our character.

"All animals require food" (p. 64).—[*"One of the Family," by F. G. Cotman, R.I. Reproduced by permission from the original in the possession of the Corporation of Liverpool.*]

CHAPTER VI

FOOD AND DRINK

ANIMALS differ much from one another in their appearance and their habits, and they also differ greatly in the food they eat. Some animals—such as lions, tigers, and cats—are *carnivorous* or flesh-eating; they hunt and kill smaller animals and eat their flesh. Many flesh-eating animals, such as the cat, are able to move silently and to stalk their prey; their feet have soft pads which make no noise in walking, and they have sharp claws to seize and hold their prey and strong muscles to carry it to their den.

Soft pads and sharp claws.

There are other animals—such as horses, cattle, and deer—which get their food from the vegetable kingdom. They live on grasses or other plants, and are called *herbivorous.* Their teeth are suited for biting and crushing the plants on which they live. Some animals which are really herb-eaters, however, can suit themselves to circumstances in the matter of food. Rats, for example, can flourish in a barn, they can thrive on the scraps from a butcher's shop, and they can

live quite comfortably on the waste matter they find in drains and sewers.

Man has a very wide power of adaptation as regards his food. He can eat and digest both animal and vegetable substances, and some of his food material is drawn from the mineral kingdom. So man is said to be an *omnivorous* or "all-eating" animal, since he makes use of all kinds of substances for the nourishment of his body — animal, vegetable, and mineral.

Teeth of a flesh-eating animal.

It seems strange at first that animals should feed themselves so differently—lions with their prey, horses with oats and grass, and boys and girls with porridge and milk or beef and potatoes. Yet the result is the same in all these cases; the body of each animal is built up and repaired in the same way. We must try to find out, therefore, whether these foods which seem to be so' different are not in some ways alike, and whether the oats and grass eaten by a horse can be compared with a dinner which any of us might eat.

Upper surface of the grinding tooth of a herb-eater (elephant).

All animals require food for the same reasons — that is, to give material for the growth and for the repair of their body, and to supply heat and energy for work; for all animals have to work—in searching for food, in defending themselves against enemies, and in other ways. When we examine the body of an animal, we find that its tissues contain a large amount of nitrogen; this

nitrogen, which is needed for growth and for repair, must therefore be supplied in the form of food. We have already said that, though the atmosphere round about us is composed chiefly of nitrogen gas, yet this pure nitrogen cannot be used by animals; it must be taken in the form of a very complex substance called *protein*, in which it is combined with carbon, hydrogen, and oxygen. Proteins are found both in animal and in vegetable substances, and so man and other animals can get the proteins which they need either from the flesh of other animals or from vegetables. Lions get protein in the form of flesh, horses get it from oats or hay, and man finds his supply either in meat or in flour and other vegetable substances.

The same kind of foodstuff may appear in many different forms. Common forms of protein are white of egg, casein or curd of milk, gluten or the sticky substance which is found in flour, and the protein of fish and meat. All these proteins act as builders and repairers of tissue.

The second function of food is to burn, and thus to produce energy and heat. We have already spoken of the body as an engine, and of the foods which contain carbon as fuel. Such foods are of two classes, *carbohydrates* and *fats*. The carbohydrates are found as either starches or sugars, so the chief fuels which are consumed in the body are starch, sugar, and fat. Perhaps you have never thought of starch as a foodstuff, but it forms the greater part of such foods as potatoes, rice, and other grains. Sugar is also found in many foods such as beet, honey, and fruits. The most common forms of fat are cream and butter, and the fat of meat.

Besides the proteins, which provide for growth and repair, and the carbohydrates and fats which give heat and energy, the body also requires certain mineral substances known as *salts*. These are found chiefly in fruits and vegetables, and also in meat and eggs. Mineral substances are needed to supply hard material for the bones, and are also necessary to keep the body in health. The want of these salts in food sometimes causes a disease called scurvy, which produces much weakness. This used to be a common disease among sailors on long voyages, as they could get no fresh vegetables or fruit. The salts required, however, are found in the juice of the lime and the lemon, and ships are now required to carry a supply of lime juice to be given at intervals to the sailors. Since this has been done, scurvy has become much less common.

Common salt is required in food as well as the mineral salts of fruits and vegetables. Perhaps you know the story that is told of an old king who had three daughters, and who wanted to know which of them loved him best. The eldest daughter said she loved him more than wine; the second, that she loved him more than bread; the third said, "I love you more than salt." The king was disappointed and angry with his youngest daughter, because she compared him to a cheap and common thing like salt, and so, in order to show him what she meant, she asked the royal cook to put no salt in the king's dinner that day. Dish after dish was sent away from the table; the king complained of their want of taste, and could not eat them. Then his youngest daughter said roguishly, "Dear father, they lack salt!" The king laughed when he saw what his

daughter had meant by loving him more than salt, without which there is no savour in other foods, and the story goes on to say that she became once more his favourite child.

In addition to all those substances, there is a large quantity of *water* in the body. About seventy per cent.—that is, nearly three-fourths—of the whole weight of the body is water, which is found in all the tissues more or less. About four and a half pints of water are given off by the body daily, in the form of waste matter from the kidneys, the lungs, the bowel, and the skin, and water is needed to make up this loss.

We now see that our food must contain these five classes of substances or foodstuffs—proteins, carbohydrates, fats, salts, and water. But the food must also contain these in a digestible form; the body must be able to break up the substances and take what it needs. Ordinary cotton fibre has almost exactly the same chemical composition as sugar, but cotton cannot be digested and absorbed by the body as sugar can, and so sugar is a food while cotton is not. Again, we must not suppose that each foodstuff contains only one of these classes of substances. Some articles do contain only one, and in order to make a meal we need to add dishes containing other substances. Almost all articles of diet, however, contain several of these foodstuffs, mixed in varying proportion.

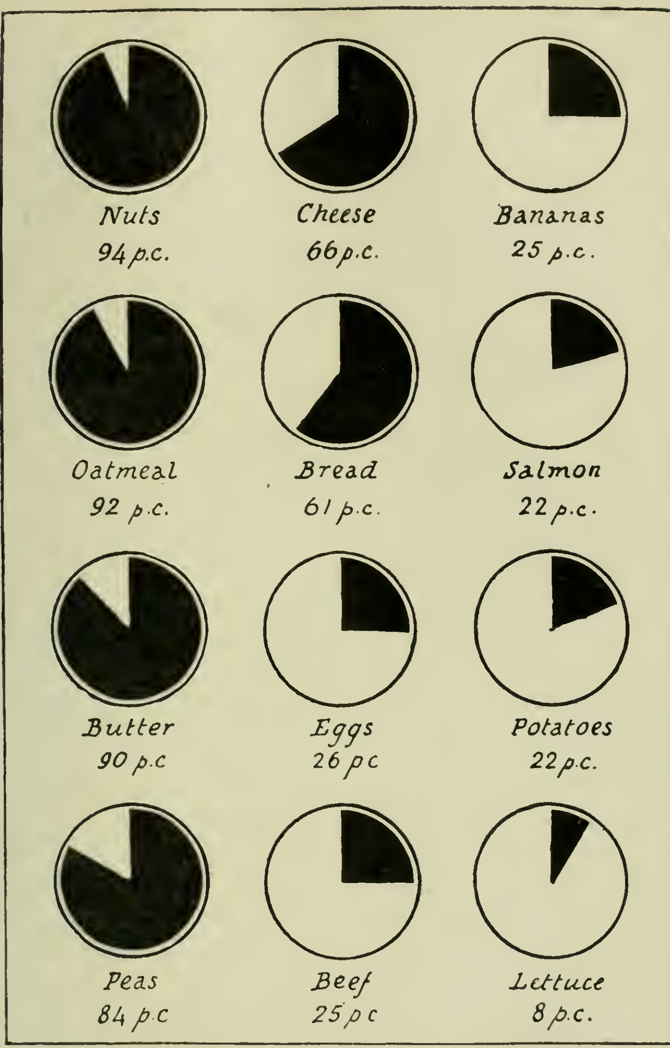
From the table on next page you see the proportion of these substances in a number of common foods. If you look at this table you will see how largely water enters into the composition of food, even of articles which no one would describe as "watery."

	Protein.	Carbo-hydrates.	Fat.	Salts and Water.
Beef (lean) . . .	20	...	2	78
Oatmeal	16	67	7	10
Eggs	14	...	11	75
Peas (dried) . . .	23	57	2	18
Beans	23	53	2	22
Bread	7	52	1	40
Potatoes. . . .	1	19	1	79
Flour	10	75	1	14
Pork (fat) . . .	10	...	41	49
Butter	1	1	82	16
Nuts	17	7	66	10
Milk	3	5	4	88
Cabbage	1	6	...	93
Lettuce	1	2	...	97
Carrot	1	10	...	89
Cheese	26	3	33	38
Bananas	22	1	1	76

Table showing percentage of nourishing materials in foods.

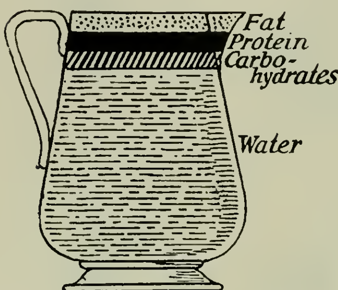
The table shows that lean meat, oatmeal, eggs, peas, and beans all have a considerable amount of protein or nitrogen-containing food. These we may call *growth* foods. Bread, rice, and flour contain a large amount of starch, which, as you will learn later, is changed into sugar in the body. Pork and butter are rich in fatty matter, and these we may call *fuel* foods. Some of these foods are of such importance that we shall consider them in detail.

The first of these is *milk*. Infants are fed on milk alone, and all through childhood milk is an important part of diet. Children thrive on milk because it contains all the necessary materials, and in the proportion which their body requires. Children



These circles show in black the proportion of nourishment contained in some common foodstuffs.

need a great deal of material for growth, and this is supplied by milk; it also gives them the fuel food which they require. Milk is not a suitable food for adults. If a man lived on milk alone, he would require to take eight pints a day. That would give him the necessary amount of fuel food, but it would also give him far more growth food than he requires. Milk may, however, be used as the only food for a time, and this is often done when people are ill. When oatmeal is combined with milk an excellent food is obtained.



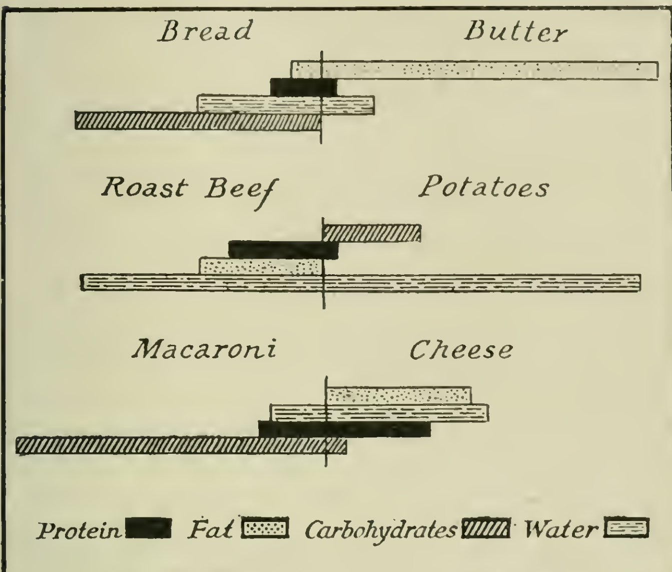
The nourishment contained in milk.

Bread is so important a food that it is often called the "staff of life." If you look at the table on page 68, you will see that bread contains 7 per cent. of protein and 52 per cent. of starch. Wheat flour, from which bread is made, is used in other forms. From it are made macaroni and many "patent foods." From Indian corn we get hominy and corn flour.

Oatmeal is one of the most useful of foodstuffs. In Scotland it was formerly the chief food of the people, although it is now less used than it should be. It is valuable because it contains all the five classes of foodstuffs, and for children there is no better food than porridge and milk.

Experience has taught people to make good combinations of food, which contain just the materials needed by the body. Oatmeal porridge and milk is one of these combinations. Potatoes and milk, or

potatoes and eggs is a common diet in Ireland. The potatoes give carbohydrate, and the milk or eggs protein. Bread and butter is another good combination; bread gives protein and carbohydrate, and



The nourishment supplied by some kinds of mixed diet.

butter gives fat. Other good combinations are beans and bacon, and meat and potatoes.

Let us now see what food material we get from an ordinary day's diet. If our breakfast consists of porridge and milk, we get from these protein, carbohydrates, fats, salts, and water. Let us suppose that we have for dinner meat and potatoes, followed by rice pudding. We get protein from the meat, and carbohydrate from the potatoes; rice also is mostly

carbohydrate, while the milk with which it is cooked and eaten contains all the five foodstuffs. We may have for supper bread and butter with milk; from the bread we get protein, carbohydrates, and salts, and from the butter we get fat, while the milk, as before, supplies all the different foodstuffs. If you think over what you eat during the day and look at the table on page 68, showing the composition of common foods, you will see that in any ordinary meal you get all the five classes of food material. The wise choice of food simply means that we select food which contains all the materials needed by the body, and which is digestible, appetizing, and not too expensive.

Children require a food supply somewhat different from that of grown-up people. As children are growing, their bodies require a plentiful supply of nitrogen: a child of five requires half as much protein as a man. For this reason, oatmeal, which contains a considerable quantity of protein, is one of the best foods for the young. Healthy children are full of energy and activity; to supply this energy, starch, sugar, and fat are necessary. Fats may be given in the form of the fat of meat and bacon, butter and cream. Sweets are good for children, as sugar produces energy and heat. The sweets must be of good quality, however, and should be eaten in moderation. If taken between meals they destroy the appetite and prevent the child from eating enough of the plainer food materials. Sugar should not be eaten the last thing at night, on account of its effect upon the teeth. Salts are necessary, and these are supplied by fruit and vegetables, and also by milk, eggs, and oatmeal. Children need a good deal

of water, and should be allowed to drink what they require.

Some substances which are largely used in our meals are not really foods at all—that is, they do not give us any of the substances which the body requires. Such things as pepper, mustard, or nutmeg are added to food in order to give it a flavour and to stimulate the nerves of taste. These *condiments*, as they are called, should not be given to children unless in very small quantities, since their appetite does not require to be stimulated through the sense of taste.

The *amount* of food which is needed varies a good deal with the circumstances of the individual and the kind of work which he does. The average amount actually eaten by a man each day has been found to be this: One pound of bread, half a pound of meat, two eggs, weighing a quarter of a pound, half a pint of milk, a quarter of a pound of fat, one pound of potatoes, two ounces of cheese, together with water to drink.

If very hard muscular work is being done, the engine—the body—requires more fuel, and so more food is taken. A labourer expends more energy than a clerk, and requires a larger food supply. A few years ago, however, it was shown by experiments on soldiers and students that good health can be maintained on much less protein food than is commonly used. Whether or not the experiments prove all that was claimed for them, it is probably true that most grown-up people eat more food than they need. Not only is this an unnecessary expense, but it leads to the body being burdened with an excess of waste material. This excess must be disposed of in some way. In the case of carbonaceous food, it is stored up in the body

as fat, and this fat interferes with the vigour of the body. The excess of nitrogenous food is disposed of by the kidneys, which often become diseased through being overtaxed with work. In the case of children, of course, growth as well as repair must be provided for, and they must be abundantly fed.

The food which one requires varies with the climate in which he lives. The Eskimo eats a great quantity of blubber, which is a kind of fat. He finds that this food suits his cold country, for fat is a source of heat. Explorers who live for a time in the far north also use a large quantity of fat in their dietary. Italian labourers live mostly on macaroni, a preparation of wheat flour, which consists chiefly of starch. Rice, the favourite food in China and Japan, is also composed largely of starch. For the production of heat and energy, man seems to prefer fatty foods in cold countries and carbohydrates in warm countries.

The food commonly used in any country also depends on what can be easily and cheaply obtained. Fruits which grow wild in the tropics may be so expensive in colder countries that they cannot be used by the poorer classes. In Scotland, salmon is now so scarce as to be somewhat of a luxury; but it was formerly so common that farm labourers sometimes made it part of their engagement that they should not have salmon for dinner more than twice a week. In some parts of China, pheasants are so abundant that they are a cheap article of diet; in other parts they are too dear to be used except by the well-to-do people.

Fortunately food need not be expensive in order to be nourishing. In many cities meals are provided in school for the school children, and it is found that the cost of a thoroughly good, plain, nourishing meal is

very small indeed. Breakfast, consisting of porridge and milk, followed by bread and butter and milk, has been provided at a cost of two cents, and dinner at a little less than three cents.

We have also to consider the *beverages* which usually form part of our dietary. *Water* is the most common beverage, and it forms a very important part of all other beverages. A considerable quantity of water is needed to make up for the daily loss from the body, and in hot weather, when we perspire freely, a larger quantity must be drunk. The habit of drinking iced water at meals, however, is not good, as this is apt to interfere with the action of the stomach and to cause indigestion.

Leaves and flowers of the tea-plant.

Next to water, probably our most common beverage is *tea*. Though now common among all English-speaking peoples, it is only some three hundred years since tea was introduced into England. At first it was so dear that only the rich could afford it, but now it is cheap enough to be used by all classes. The tea which we drink is an infusion of the dried leaves of a shrub which grows most abundantly in China and India. In China when one is given a cup of tea the flowers of the plant float on the surface of the fluid. Only the well-to-do people can afford this fine tea, which costs from four to five dollars a pound. The

tea which is exported from China is of a much coarser quality. Sometimes English people who live in China send home to London for their tea, as they prefer the coarser kind, and cannot buy it in the Chinese shops.

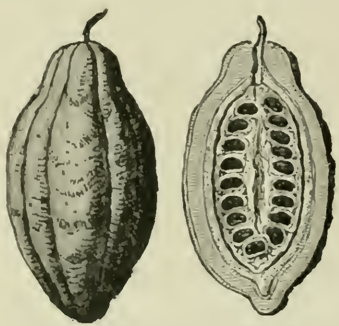
Tea is not a food, and contains no nourishment for the body. It is a stimulant—that is, it excites the nerve cells to action. Unlike alcohol, tea does not produce depression afterwards. The stimulating substance in tea is called *theine.* Tea leaves also contain *tannin*, the substance which is used to "tan" or harden leather, and when tea is infused for more than three minutes the infusion contains tannin. The bad effects of tea are due to long infusion, as tannin interferes with the digestion of our food. Children under ten or eleven years of age are better without tea, and even when they are older the tea which they drink should be very weak and should contain plenty of milk.

Leaves and berries of the coffee plant.

Coffee is made from the seeds contained in the berry of a shrub which grows largely in Arabia, the West

Indies, and Brazil. The seeds are roasted and then ground, and an infusion is made from the powder. Coffee is a stimulating drink, the stimulant contained in it being *caffeine*, which is the same in composition as the *theine* of tea. The pleasant aroma of coffee is due to an oil which is set free during the roasting process. Coffee should not be given to children.

Cocoa is another favourite beverage. It is prepared from the seeds of a plant which grows in the West Indies. Cocoa has some value as a foodstuff, as it contains a considerable proportion of fat. Chocolate is prepared from cocoa by removing the fat and adding sugar. Cocoa is a very useful beverage for children, and is only slightly stimulating. Probably a good deal of the pleasure we feel in drinking tea, coffee, and cocoa arises from their being taken hot. Hot water, sweetened, is a quite agreeable beverage.



The fruit and seeds of the cocoa plant.

A number of common beverages are known under the general name of *aerated waters*—that is, water which contains carbon dioxide or carbonic acid gas under pressure. Soda water is an aerated water to which soda has been added. Other aerated waters, such as lemonade, are specially flavoured, and also contain a considerable amount of sugar.

Many of our common beverages contain *alcohol*, but this substance is of so much importance that we must deal with it in a separate chapter.

Most of our food is prepared for eating by being *cooked*. Charles Lamb in one of his essays gives a fanciful account of how cooking was discovered. He says that an ancient Chinese manuscript tells of a swineherd, Ho-ti, who left his house in charge of his son Bo-bo. During his absence Bo-bo set the cottage on fire and burned it to the ground, and the pigs perished in the fire. Bo-bo smelt the fragrant odour of roast pig, and when he tasted it he found it delicious. Ho-ti afterwards shared in this dainty, and in order to enjoy it he occasionally burnt down his house. The fashion spread until it became quite a custom to burn down one's cottage. Then at last a sage arose who showed that a pig might be roasted without burning down a house.

Although Lamb is only joking when he tells this story, it is likely that the effect of heat upon food was discovered at first by some accident. It was found that food was made more palatable by cooking, and so the practice arose. But cooking does more for food than merely rendering it palatable. Heat kills disease germs, and such germs as may be in the food are destroyed by cooking. Some foods are made more digestible by cooking. When starch is cooked, the starch grains burst open, and are more digestible in that form. Cooked food is generally softer and more easily chewed, and so it is better prepared for the action of the juices of the stomach. Food is usually eaten warm after cooking, and this warmth makes it more agreeable and also more digestible. It is not every form of cooking, however, that is helpful to digestion. Frying, for example, though a quick and easy way of cooking food, is apt to make it hard and indigestible, and the coating of fat which the

"*The 'staff of life'*" (p. 70).—[*Harvest-Time in Canada, by Cyrus Cuneo, R.I. By kind permission of the C.P.R. Co.*]

food receives hinders the action of the digestive juices. The art of cooking is a most important one, so far as health is concerned, but we cannot discuss it fully at present.

In addition to choosing food of a suitable kind, we must do our best to secure that the food we eat is *pure* and *clean*. Impurities are often added to food by dishonest traders in order to make it cheaper. A food may be cheap and yet quite good, but sometimes men mix inexpensive things with the food so that their profits may be greater. Water is often added to milk, sand may be mixed with sugar, and sometimes tea-leaves which have been used are dried and mixed with the tea that is to be sold.

It is not always possible to tell whether a food is pure or not, unless it is carefully examined by a chemist. Most countries have laws against the adulteration of food, and employ chemists to examine samples of what is sold in order to ensure its purity.

Some of the impurities which spoil food are added to it accidentally, and not on purpose. These are chiefly the small organisms or microbes which cause disease. Milk frequently contains the germ which causes the dread disease tuberculosis; and other infectious diseases, such as scarlet fever, are frequently spread by milk. The germs of enteric fever, or typhoid fever as it is commonly called, are usually carried by the water supply. Hence it is extremely important to know where we get our milk and our water, and to make sure that there is no risk of their being supplied to us impure. The most strict cleanliness is necessary in dairies and places where milk is handled in order to exclude all germs of disease, and unless we are perfectly sure of its purity the milk should be pasteurized before

using, especially for children. To pasteurize milk it should be heated to 140° F. and kept at that temperature for twenty minutes. It should then be cooled to 45° F., and should remain at that temperature until it is used. This destroys the germs of diseases such as tuberculosis, scarlet fever, and diphtheria, which may be carried by milk.

The water supply of towns is a matter of great importance for health. The water is usually filtered or purified before it enters the pipes which convey it to our houses. People who live in the country are often very careless about their water supply. They may use water from wells, from streams, or from ponds, and if impure water is allowed to find its way into these, the result may be the appearance of some disease. It is always a wise plan to boil water before using, unless we are quite certain that it is pure.

The food which we buy may be pure, and yet we may allow it to become impure or to "go bad" before it is used. All vessels into which food is put should be absolutely clean. Food should never be left lying exposed to the chance impurities which are always present in the air or in the dust of our houses. If it is to be kept for some time it should be put into a cool, ventilated place, and should be kept covered. Otherwise it is exposed to the germs which float in the air, and to the pollution of flies.

Many foodstuffs "go bad" or begin to decay very quickly, especially during hot weather. Decay or decomposition is due to the action of small organisms which change and split up the substances which the food contains. When food decomposes it may have an unpleasant smell and a disagreeable taste. If it is eaten in this state, it is apt to cause serious illness.

Food which is liable to decay must be bought in small quantities from time to time as it is needed, and we should be careful to see that it is quite fresh and good before using. During cold weather food can be kept fresh for a much longer time. Cold prevents the growth of the germs or small organisms which cause decay. That is why we find the ice-box so useful for keeping food in during summer. It has been found that meat, fish, fruit, and other articles will remain good for a long time if they are frozen, and not allowed to thaw till they are to be used. Ocean steamships are now fitted up with machinery for freezing, and carry to Europe large quantities of frozen beef from South America and frozen mutton from New Zealand. The heat of the tropics does not injure it, as it is kept in cold chambers during the whole voyage. In large cities there are cold storage buildings where fruit and other foodstuffs can be kept good for months. This is very convenient, as we can have summer fruit to eat in the middle of winter. But although the freezing keeps it from decay, the flavour is never quite the same as when we get it fresh from the orchard.

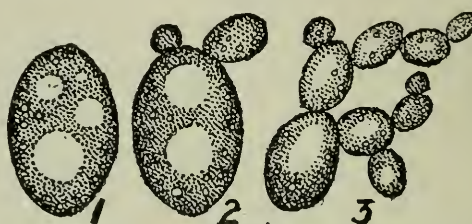
CHAPTER VII

ALCOHOL

When a man is wanted to fill any situation, the employer must see that the man he selects knows how to do the work required. If a gardener is wanted, he chooses a man who has a good knowledge of plants and of soils; if a chauffeur, one who knows how to run and repair an automobile, and so with all kinds of skilled work. It is not enough, however, that the man should be a good workman; he must also be a reliable man. If you were to ask any one who has a large number of men in his employment what is the most common cause of good workmen failing to give satisfaction, he would almost certainly reply, "Drink." Men who are applying for work know this also; they know that one of the best recommendations for a situation is to be a total abstainer from alcoholic drinks. Let us try to understand how it is that the use of alcohol makes a man unreliable and ruins his prospects.

Alcohol is a substance which is prepared from sugar. You already know that sugar is a foodstuff of great value to the body as a producer of energy, and you know that it is made up of carbon, hydrogen, and oxygen. If we dissolve some sugar in water, and add to this a small quantity of yeast, keeping it warm all the time, a curious change takes place. Yeast

is a plant organism or germ of a very simple type, and in the sweet warm liquid it multiplies very rapidly. The plants act upon the substance of the sugar, and some of its carbon and oxygen are set free. This escapes from the liquid in bubbles of carbon dioxide or carbonic acid gas, which, as you already know, is the waste gas that is produced by burning and that we breathe out from the lungs. In the meantime the sugar is changed into a new substance, and that is



How the yeast plant increases in numbers—(1) *single plant* ; (2) *buds forming* ; (3) *a chain of plants.*

alcohol. The change which the yeast produces in the liquid is called *fermentation.*

Alcohol can be made by fermentation from a great many different substances, the most common being barley and other grains, grapes, and potatoes, and from these many kinds of alcoholic or intoxicating drink are produced. Ale or beer is an infusion of malted barley fermented with yeast to produce alcohol and flavoured with hops; whisky is a spirit distilled from a similar infusion of barley, Indian corn, or other grain; wine is the fermented juice of the grape, and brandy is a spirit distilled from the grape juice. These and other drinks differ much in the amount of alcohol and in the flavouring matters which they contain.

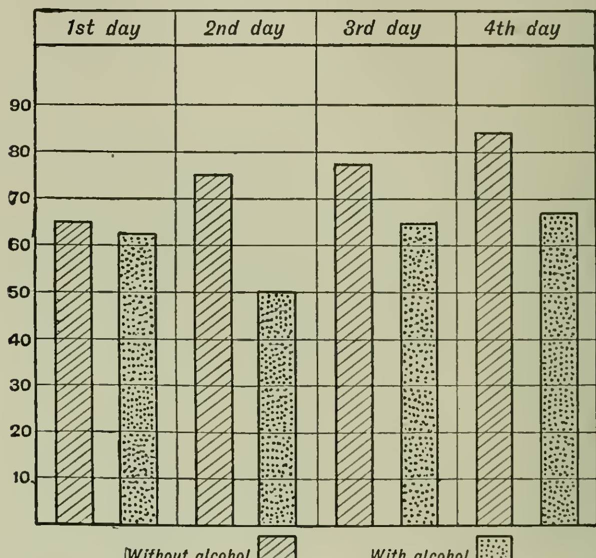
Such drinks are found in almost every country,

and many people use them in the belief that they are of great benefit. Let us see first of all what people *say* alcohol does. When a man leaves a friend's house on a cold winter night, he is sometimes urged to take a glass of whisky "to keep out the cold." Perhaps he takes it, and in a few minutes he feels a warm glow all over his body. But is he really warmer? No. What has happened is this: the alcohol makes more blood flow to the skin, and this gives the man a feeling of warmth. But in the skin the blood is exposed to the cold air, and the result of this is that the heat of the body is wasted. Instead of keeping out the cold, therefore, alcohol cools down the body and makes us more liable to take a chill. Men who go on exploring expeditions to the arctic or the antarctic regions know this well. They do not take alcohol. The lumbermen in our forests suffer more from the winter cold if they use alcohol, and many a man who uses whisky to "keep out the cold" ends by being frozen to death.

You may say, then, that since alcohol does not make the body warmer but rather colder, it ought to be a useful drink in hot countries. This is not the case, however. People who live in the tropics know well that the men who stand the heat best are those who never touch alcohol. Many a place whose climate is condemned as "unhealthy" would not get such a bad name if the men who live there were more careful to avoid the use of alcohol. It is either useless or dangerous in a cold country, and very harmful in a hot one.

People sometimes say that alcohol enables them to work better, and for a long time this was believed to be true. Then scientific men set themselves to

inquire whether this is really the case, and to find out how alcohol affects our working power. One test that was made was the adding up of long columns of figures, and it was found that after taking alcohol the men did this work more slowly and also made more mistakes. Another set of tests was given to men



This diagram shows the comparative amount of work done, in four days' tests, with alcohol and without.

who were setting up type for printing, and they too were found to work more quickly and more accurately without alcohol. Soldiers were tested in rifle-shooting, and they were found to shoot more quickly and to make better scores without alcohol than when they had a moderate supply of beer.

The men with whom these tests were made were

greatly surprised at the results. They all *thought* that they were working better after they had taken a little alcohol. So it appears that alcohol not only prevents a man from doing his best work, but it also deceives him into thinking that he is doing well when the results tell another tale.

People often say that alcohol is a good thing for making the brain brighter and clearer. They tell us of men who are rather dull and stupid at most times, but who talk brightly and cleverly when they have drunk a little alcohol. Let us see how this is. When we come to speak of the brain, you will learn that the higher parts of the brain control the action of the lower parts, so that we may take time to think before we speak, and to judge before we act. But alcohol affects the higher parts of the brain first, and when these are thrown out of order, and do not exercise control over the lower, the man speaks before he thinks. People who speak without thinking do say clever things sometimes, but they also say a great many things that are foolish and ought not to be said.

We have found, then, that the three things claimed for alcohol are really untrue—it does *not* keep out the cold, but rather lets it in; it does *not* improve one's working power, but makes it worse; and it does *not* give brightness or cleverness to the brain, but takes away its power of control over what is said. Now let us see how alcohol really does act on different parts of the body, so far as experiments can show us.

In a later lesson you will learn many things about the blood, but we must mention here how it is affected by alcohol. There are white cells floating about in the blood; their duty is to protect the body. They attack and destroy disease germs which get into the blood,

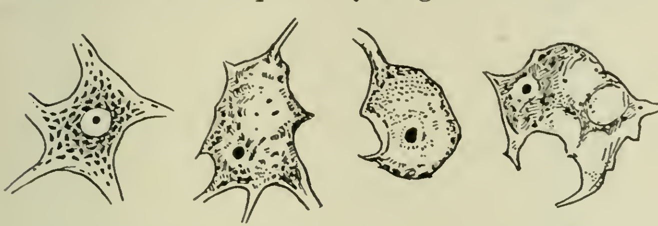
as can be seen with a microscope. But when alcohol is taken into the blood, the white cells become less active. They no longer attack and destroy the germs of disease. They have lost their power; they are paralyzed, as we say, when a person loses the power of moving his limbs. A drinker of alcohol, therefore, cannot resist the attacks of disease. He has destroyed the vigour of the cells which guard his body.

There is a serious disease of the lungs which is called pneumonia—that is, an inflammation due to the presence of certain organisms or microbes. Every doctor knows that a drinker who takes pneumonia is much more likely to die than one who abstains from alcohol. It is the same with that terrible disease tuberculosis. The body of a drinker, in which the white cells are being poisoned by alcohol, cannot fight against the germ which causes the disease. And not only is such a man less able to resist the disease; he is also more likely to be infected by it, for the bars and public-houses where men go to drink are an active means of spreading such diseases, owing to the bad air and germ-laden dust. Illness generally is more frequent among those who take alcohol than among abstainers.

The blood contains a vast number of red cells, and they are also affected by alcohol. Their work is to carry oxygen to the tissues. But when there is alcohol in the blood these cells will not part with their oxygen so readily. The tissues are not so well supplied with oxygen, therefore, and their waste matter is not so completely oxidized or burned up. Hence it tends to remain in the body and to accumulate, and that is how drinkers often become stout. The fat is not supplied with sufficient oxygen to burn it up and produce energy in the body. We have already seen

that alcohol causes a larger quantity of blood to be brought to the skin. This makes the flow of blood through the body more sluggish and less vigorous.

If we were to go over all the organs and all the different kinds of tissue in the body, we should find that alcohol has an injurious or destructive effect upon every one of them. If you think on the harm done to the blood alone, and how much the health of every part of the body depends on it, you will see that it would make this chapter very long indeed if we were



1 2 3 4

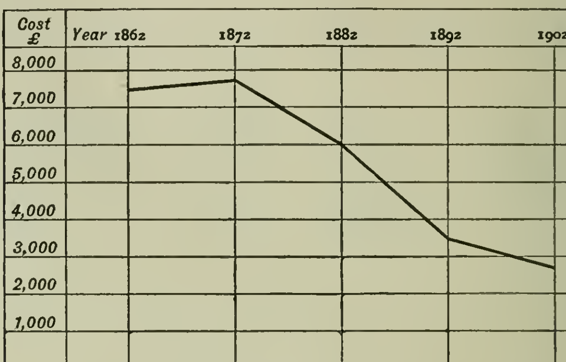
"*Alcohol destroys the cells of the brain.*" 1 *is a healthy cell ;* 2, 3, *and* 4 *show decay due to alcohol.*

to go over all the injuries worked by alcohol. We should have to describe the way in which it injures the heart, inflames the stomach, hardens the liver, destroys the kidneys, and ruins the brain.

Instead of doing all this we will try to realize how alcohol destroys the cells of the brain, as an eminent London physician has shown us. The change made in these cells can easily be seen ; the nucleus or active part of the cell and the fibres which link the cells together are alike affected with decay. And the worst of this poisoning of the brain cell is this, that their change affects the man's character and conduct in the most painful way. A truthful man begins to tell lies and to deceive. A careful person becomes reckless. A shrewd,

prudent man becomes foolish and careless. An affectionate, kindly man becomes cruel even to those whom he loves best.

In all our large cities there is an institution for the care and treatment of those who are insane—that is, who are no longer capable of taking care of themselves, or whose "minds are affected," as we say. Insanity is a disease of the brain. Ask the doctor



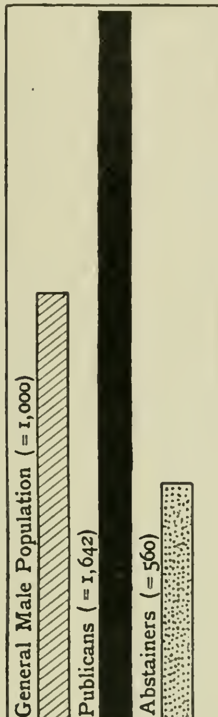
This diagram shows how the quantity of alcohol used in the hospitals in London, England, has decreased, although the number of beds has increased during the same years.

in charge of such an institution how many of those people owe their diseased brain to the use of alcohol, and he will answer, "One out of every five."

Every year something new is being found out about the action of alcohol, and the more that we find out the more do doctors condemn its use. In our best hospitals it is never used as an article of diet, but only as a drug, and even for such purposes it is much less used than it was a few years ago.

There is another danger in the use of alcoholic drinks which we have not mentioned. Many of them

are not pure, but are mixed with substances which are as harmful as alcohol, or which have even worse effects upon the body. They are added to alcoholic drinks in order to cheapen their manufacture, and to give a bigger profit to the man who makes and sells such drinks.



This diagram shows the death-rate of teetotalers and of saloon keepers respectively, compared with the rate of the general population.

Thus far we have been considering alcohol from the doctors' point of view, and learning how its use affects the health of the body. Let us now look at it from another point of view, and see what business men have to tell us. The chief question a business man has to consider about anything is, "Does it pay?" Let us see, then, how the use of alcohol is found to pay.

You know that most prudent men insure their lives—that is, the man agrees to pay to a life insurance company a certain sum of money every year, and in return for this the company agrees to pay to the man's relatives a certain sum — say, a thousand dollars — when he dies. Even if the man dies after paying only one or two yearly premiums, the company pays the thousand dollars, but in this case they lose on the transaction. On the other hand, if the man lives longer than the company had expected, they will

gain by the larger number of annual payments. Insurance companies have made very careful calculations, therefore, of how long a man is likely to live. They have also tried to find out what classes of people live longest, for you can see that a man who is likely to live long ought to be able to insure a thousand dollars for a smaller yearly payment than one who is likely to die at an earlier age. As a result of their inquiries and calculations, life insurance companies now insure total abstainers at a lower rate than others, because they find it clearly proved that such men live longer. In this matter, therefore, we see that it does not pay to use alcohol.

Railway companies have also to consider what pays and what does not, and they have learned that the use of alcohol is one of the things that do not pay. Of course, it would never do to have a train in charge of a man who is occasionally "the worse of drink," as we say; it might lead to the most disastrous accidents. Any man who is known to drink too much is, therefore, liable to be dismissed. But many railway managers go farther than this. Even a moderate quantity of alcohol has effects upon the body which the man is not aware of, as we saw in the case of the tests in rifle-shooting and type-setting, and we know that men who are training for an athletic contest give up the use of alcohol in order to have their muscles and nerves in the best condition. Now, in railway work, and in many other kinds of work as well, an emergency often happens when a man must make some sudden effort of strength or skill, or take some sudden decision. And the power of the man to do this may depend on whether his brain and his muscles are at their best, or whether they have been

put slightly out of order by what he would call a harmless glass of beer. The man may be just half a second too late in deciding what to do, or his accuracy and quickness of hand and eye may be a little below what he expects, and so an accident happens which would otherwise have been avoided. We can quite understand, therefore, why some railway companies and other employers of labour should find that it "pays" to employ none but abstainers in certain responsible positions.

In all our large towns and cities we find men who fail in life. Some of them seem unable to earn an honest living in any kind of work. They sink gradually into poverty, and find shelter in some of those terrible "slums" which are found, like disease spots, in all our great cities. Some of them give up the attempt to live honestly, and prey upon society by stealing or other forms of crime. If we ask any missionary who is working in the slums of our cities what is the chief cause of their poverty and misery, he will answer, "Drink." If we ask the governor of the prison what is the chief cause of men turning to crime, he will answer, "Drink."

You may ask why men go on taking alcohol if all these things which we have said can be proved against it. One reason is that many people are ignorant of the real effects of this poison, and another reason is that when one forms the habit of taking alcohol and gets a taste for it, he finds it very hard to give up the habit. The craving for the stimulus of alcohol is often too strong for a man to resist, although he may know quite well the harm it is doing him; that is what makes a man a drunkard. Now it is certain that no one really *wants* to become a drunkard, and to have

his health, his mind, and his career in life ruined. Yet a large number of men, and of women too, actually become the slaves of drink. There is a danger here which young people must beware of, and luckily there is a sure way of avoiding the danger. The only absolute safeguard against all those evils which we have been considering, is just the simple plan of never touching alcohol.

CHAPTER VIII

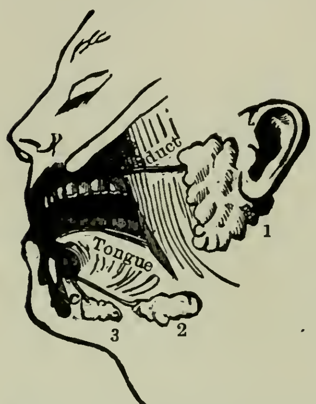
DIGESTION—I

Chemists have shown that foodstuffs are built up of four elements—carbon, hydrogen, oxygen, and nitrogen. Chemists study the elements of which substances are made, and also how a substance may be changed into something quite different by adding some new element or taking away something which it contains. Thus chalk can be changed into a different substance by pouring over it an acid, part of which joins itself to the substance of the chalk; it can also be changed by great heat. You may have seen a workman pour water over a heap of quicklime. Soon steam rises from it, and the pieces of lime split up and crumble down into a white powder; the lime has been changed into a new substance. Burning or combustion, as we have seen, is a change of a similar kind; the carbon of the fuel joins with the oxygen of the air, and a new substance, carbon dioxide, is produced. Many chemical changes of this kind are used in manufactures. In glass-making, soap-making, and brewing, new substances are produced by chemical changes.

The workroom of a chemist is called a laboratory. Perhaps you have been in a chemical laboratory, and have seen the benches or tables for working on, the gas-burners for heating, and the rows of bottles containing

the different liquids which the chemist may need to mix with any substance which he is examining.

Digestion consists in a series of chemical changes which prepare our food for nourishing the body, and these changes are caused by certain liquids being poured into the food. There are three places in the body where those liquids are prepared by groups of glands, and where the food is changed by being mixed with them. These "chemical laboratories," as we might call them, are the *mouth*, the *stomach*, and the *intestine*. The heat required for these changes is supplied by the general warmth of the body. We shall understand best the changes which take place during digestion if we examine that process stage by stage, beginning with our taking the food into the mouth.

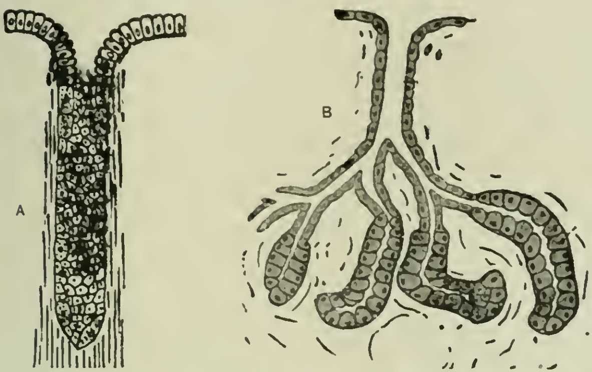


Mouth, with salivary glands. Note the three glands—(1) *in front of the ear;* (2) *under the jaw; and* (3) *under the tongue.*

In the *mouth* the food is chewed by the teeth. The front teeth are formed for cutting or biting the food, and the side and back teeth for grinding it. Thus the food is divided into small pieces, and at the same time it is thoroughly mixed with the first of those fluids which we have mentioned as changing the substance of the food. This fluid is called the *saliva*. It comes from certain glands or bag-shaped structures, called *salivary glands*, whose walls are built up of the cells which produce the fluid, and these glands have openings

or ducts leading into the mouth, through which the fluid is poured out. One of these ducts opens above the upper teeth, and the others below the tongue.

The effect of the saliva upon the food is to change the starch into sugar. If we take a piece of bread, which contains a good deal of starch, and chew it for some time, we find that after a little while it begins to taste somewhat sweet; its starch has been changed into



The digestive glands are of two types—(A) *simple or tube-like, and* (B) *compound or branching.*

sugar by the saliva. This change is brought about by a process which is called fermentation. In the chapter dealing with alcohol you learned that sugar is fermented or changed into alcohol by the action of a small living plant called yeast. The ferments which act upon the food in the body are not living ferments like yeast, so far as we know at present. They resemble yeast in this respect, however, that a small quantity of the fluid can ferment or act upon a large quantity of food material. In the case of the saliva, as we have said, the ferment acts upon the starch in the food and converts it into sugar.

During the first few months of a baby's life, the saliva in its mouth contains very little ferment, and that is the reason why young babies should not get starchy foods such as bread.

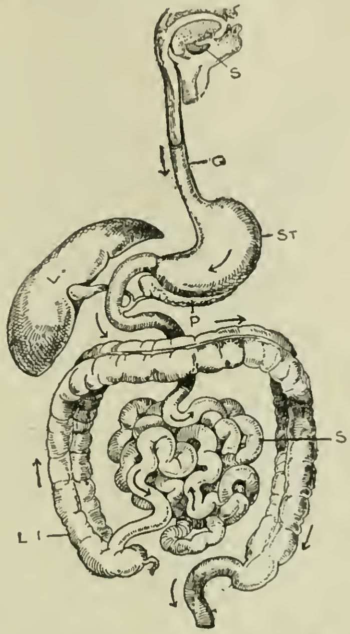
When we speak of something which is very delightful and appetizing, we sometimes say, "It makes my mouth water," and this may be literally true. When the sensations of sight tell of food that looks extremely desirable, and the sensations of smell proclaim its fragrance, the glands of the mouth prepare for its reception by pouring out a supply of saliva. The saliva is necessary to enable us to chew and to swallow our food; when there is a want of saliva, as in fever, the mouth feels dry, and solid food cannot be eaten with any pleasure.

On the tongue there are certain nerve structures which give us the sense of taste when the food comes in contact with them. If food tastes bad, we feel we cannot swallow it. To some extent, then, taste helps us to select our food, but taste is not always a safe guide. Some things which have a very pleasant taste are not good for the body, and others are helpful although their taste is unpleasant. Rich or sweet foods, for example, taste very good, but they soon upset the process of digestion; while oatmeal porridge, although an excellent food, is much less attractive to the taste. On the whole, however, if we accustom ourselves to plain, wholesome food, and do not let our taste nerves fall into bad habits, we come to enjoy the taste of simple food more than that of luxurious but less nourishing dishes.

Before the food is swallowed, it should be so well chewed and mixed with saliva that it is soft and pulpy. This process of chewing or mastication cannot be rightly done unless the teeth are good, and defects in the teeth

are a very common cause of indigestion. When the food reaches the back of the mouth it is swallowed, and that is the last step in the process of digestion of which we are conscious, if we are in perfect health.

The food, however, continues on its way towards complete digestion, passing down a tube called the *gullet* into the *stomach*, the second of the chemical laboratories of which we spoke. The stomach is a bag with muscular walls, and in these walls are certain glands which prepare the second of the digestive fluids. The contraction of the muscles in the walls of the stomach keeps the food moving about, so that it is churned and mixed with the fluid.

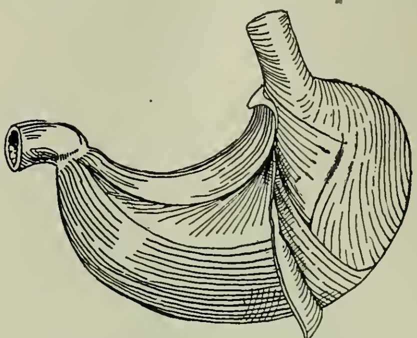


This diagram shows a general plan of the digestive system. Note the salivary gland (S), *gullet* (G), *stomach* (ST), *pancreas* (P), *liver* (L), *small intestine* (S.I.), *and large intestine* (L.I.).

This digestive fluid contains two ferments, which act upon two different kinds of food material. One of them acts upon the materials which contain nitrogen, or proteins as we have called them. The protein is split up by this ferment and a simpler substance is formed from it which can be taken up and made use of by the body.

The second of the stomach ferments is one which

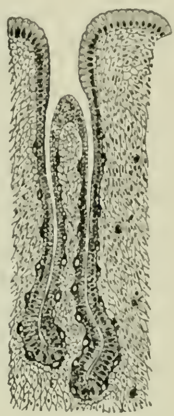
curdles milk. You know how we curdle milk in order to make junket, which is always a favourite dish in hot weather. We warm the milk and stir into it a small quantity of a substance called rennet, and then allow it to stand until the milk turns into a soft white curd. This is exactly what happens in the stomach. Some of the cells pour out a substance called *rennin*, which is almost the same as rennet, and by it the milk in the stomach is curdled. The stomach acts best when the pieces of curd are small. That is why children should drink milk slowly; the stomach can then form curd from it in small pieces.



The stomach. Note the direction of the muscle fibres in its various coats.

But, you may ask, how do we know what goes on in the stomach? We are quite unconscious of all these things which are being described: how have they been found out? One of the most remarkable ways in which the stomach has been studied was in the case of a man named St. Martin. He was a Canadian, employed in the fur trade, and he was badly wounded by the accidental discharge of a gun. So severe was the wound that an opening was made in the wall of the stomach, and thus it was possible to see what went on there. The changes which took place from time to time were carefully studied by a doctor, whose servant St. Martin had become.

Almost immediately after a meal the stomach begins to pass on the food for further change to the next part of the digestive tract. During this period the muscles of the stomach are in constant movement, and their contraction changes the shape of the stomach from time to time. The starch in the food has now been turned into sugar, the protein has been changed into a simpler substance, and the milk has been curdled.

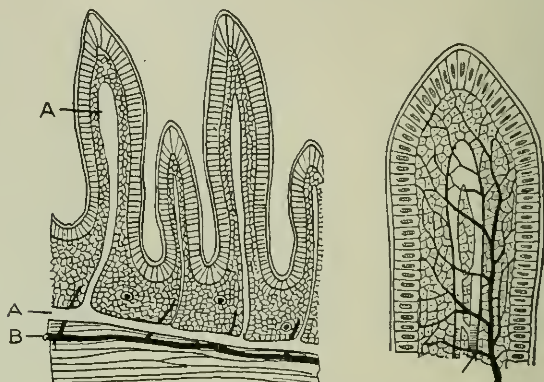


A gland from the inner wall of the stomach.

From the stomach the food passes to the next of the chemical laboratories, as we called the places where chemical changes take place during digestion. This laboratory is called the *intestine.* The intestine is a very long tube consisting of two portions—the small intestine, which is about twenty feet in length, followed by the large intestine, which is about six feet long. The lining of the small intestine is covered with tiny finger-like projections which give the surface a velvety appearance. The walls of the intestine contain gland cells similar to those of the mouth and of the stomach. They also contain muscular fibres, by the action of which the food is stirred up and mixed as it was in the stomach, and is kept moving steadily onward through the tube. While in the intestine, the food is also mixed with a digestive juice from a large gland called the *pancreas,* and with bile from the *liver.*

The juice sent by the pancreas into the intestine is one of the most important of the digestive fluids. It contains three ferments—one which converts starch

into sugar, another which acts upon fat and prepares it for being used by the body, and a third which changes protein into a simpler substance. The fluid from the walls of the intestine helps the action of the juice from the pancreas. So you see that in the intestine the three substances which form our food are completely digested—the carbonaceous parts, the nitrogenous parts, and the fats—and the food is now



Villi from the inner wall of the small intestine, enormously magnified, to show the blood-vessels (B) *and fat tubes* (A).

ready to be taken in or absorbed by the various tissues of the body.

Each of the finger-like projections which we have mentioned on the surface of the intestine is called a *villus;* it is well supplied with blood, and the digested protein and sugar pass directly through the thin wall of the villus into the blood. The digested fat is taken up by special tubes, very fine and small, which unite to form a large tube, and by this tube the fat is carried up to a large vein in the neck, where it is poured into the blood. Thus the digested nitrogenous

and carbonaceous materials pass directly into the blood, and the fats indirectly.

But all that we eat is not digested and taken up into the blood as nourishment. If the food is very unsuitable for the body, or if it is eaten too hastily, it may be ejected at once from the body by means of vomiting. Most of our food contains some parts which cannot be digested. All this waste matter from the food, together with a certain amount of fluid, is passed on to the large intestine, and thus leaves the body.

When you read of all those wonderful chemical changes which take place in the laboratories of the body, and all the processes by which the nourishment is carried to every part of it, you may say, "Well, all these things go on without my knowledge, and they are beyond my control. If I have a good digestion, so much the better; but if I have a poor one, I can't help it." There are many ways, however, in which we can help our digestion. It will certainly do no good to be always thinking about what we eat and how we are likely to feel if it does not digest well; people who keep their minds turned to such matters as these are always miserable. But there are good and bad habits as regards eating, and we ought to take care that our habits are good ones. When we have done that, we can do no more, and our best plan is to forget that we have a stomach at all.

You already know that your "mouth waters" at the prospect of enjoying some favourite dish. So do the other digestive glands in the body; they seem to anticipate and prepare for the meal by getting ready the fluids which will be required. The sight of clean, appetizing food served in a neat and attractive fashion

sets the digestive glands in action. The usual preparations for a meal have the same effect. Washing the hands, brushing the hair, and tidying the clothes before sitting down to table are all of a certain value in promoting digestion. The opposite effect is produced by food that looks unpleasant, by soiled tablecloths and dishes of doubtful cleanliness. One way in which we can help the digestive process in our bodies, then, is by having our food properly served and by being clean and tidy at meals.

Another thing which helps the work of digestion is regularity. The digestive glands get into the habit of being ready for food at certain times, and the feeling of hunger is a signal to us that they are ready. The more regular our meal-times, the better will our digestive organs work.

Again, it has been found that if an animal is teased and made angry, the stomach movements of which we have spoken become slower and fainter, and finally cease. This explains how it is that any strong feeling, such as grief or anger or excitement, causes a loss of appetite. This gives us a hint that it is well for the sake of health to cultivate a quiet mind at all times, and particularly not to choose meal-times for talking or thinking of disagreeable subjects.

It is of course necessary that food be plain and wholesome if the digestion is to be good. Experiments show that the digestive glands get into the habit of producing the juices suitable for the food we eat. If a meal consisting chiefly of bread and butter, for example, is in the stomach, the pancreas gets ready to supply the fluid required for starches and fats, while the presence of meat in the stomach causes the pancreas to prepare the special ferment for protein. If our food is wholesome

"After dinner rest awhile" (p. 106). *The children in the open-air "Forest School" of Toronto enjoy a nap under the trees after dinner.*

and digestible, the digestive glands are ready to do their work on it.

A healthy life usually produces a good appetite, and when we have a good appetite we are likely to have a good digestion. Hence digestion is aided by our having plenty of fresh air, plenty of work and exercise, and sufficient rest.

Digestion is greatly assisted by good mastication, and it is, therefore, of great importance that the teeth should be well cared for. When the teeth are bad, pieces of decayed matter get mixed up with the food and pass into the stomach, acting as a kind of poison. When many teeth are lost, the food cannot be properly chewed, and it is not sufficiently broken up for the digestive juices to reach all parts of it. Artificial teeth are of great use when necessary, but they are never so good as the natural ones.

Active exercise or work immediately after a meal hinders digestion. A large amount of blood requires to flow through the walls of the food canal while digestion is going on, and this cannot be supplied if at the same time blood is being sent through the muscles for their exercise. There is an old saying, "After dinner rest awhile," and the advice is quite sound.

One habit is of very great importance, and that is regularity in getting rid of the waste matter from the intestine every day. If the food waste is allowed to remain in the body, bad health is sure to follow. In this, as in all matters connected with the healthy action of the body, the habit of regularity is most valuable.

CHAPTER IX

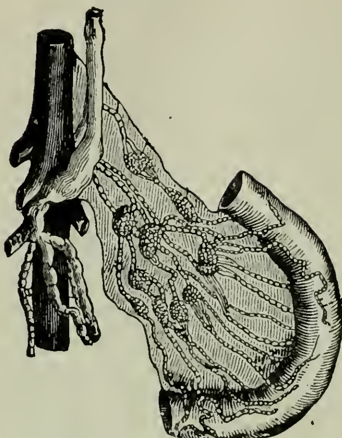
DIGESTION—II

We have already traced the digestion of food until the nourishing parts of it are absorbed through the wall of the intestine. We saw that the nitrogenous matter and the sugar (which now includes the digested starch) are passed directly into the blood. The fat, as we have seen, flows into special tubes, and is taken by these to a large vein in the neck, where it is also poured into the blood.

The material which is not digested is passed down the bowel. We must not suppose, however, that because this material cannot be digested it is therefore of no use in the body. In the intestine the food is moved about and passed onward while the nourishment is being absorbed from it. This work is carried on by the contraction of the muscular fibres in the wall of the intestine, and it is most easily done when the food has some bulk and can thus be laid hold of by the muscular contractions.

Sometimes people joke about how we shall take our food in the future. They tell us that by-and-by chemists will be able to compress all the nourishment we require into the form of pills to swallow, and that there will be no need to waste time in cooking and eating our meals. But you can now see that even if

we had such pills, they would not serve all the needs of the body. Our food must have a certain bulk in order that the contractions of the intestine may be able to mix up and move about the whole mass, so that it may be thoroughly digested and have its nourishment absorbed.



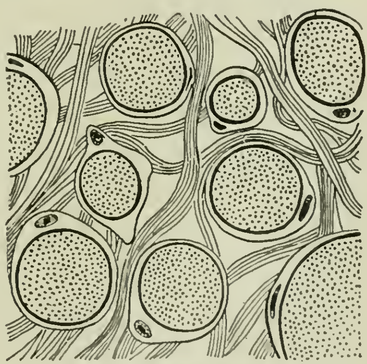
Fat ducts leading from the wall of the intestine.

The waste matter is moved along the bowel by the contraction of the muscles in its wall, but these muscles do not act well unless they are used regularly. Their action also depends upon the general health being good. Regularity and plenty of exercise and fresh air are the things most necessary to keep the intestinal muscles in good condition. If the waste matter is not expelled from the body daily, it decomposes, and poisons are produced within the body which cause discomfort, headache, and a general feeling of ill-health. A doctor who had charge of an institution containing some hundreds of young people used to say that he would have little or no work to do if they would attend to two things; these things were, first, the care of the teeth, and, second, the daily removal of waste from the bowel.

If the muscles of the bowel have been allowed to become sluggish and do not act well, many people adopt the very foolish plan of taking medicine constantly. Now medicine is useful on an occasion, but it is a

bad practice to take medicine frequently unless it is required for some special reason. The muscles get into the habit of waiting for the stimulus of the medicine, and they become less able to act without it. The right thing to do is to practise regularity, to lead a life of more active movement, and to drink plenty of water. It is important also to eat food which contains a certain amount of bulky material or "ballast" as well as nourishment, such as fruit, vegetables, porridge, and brown bread.

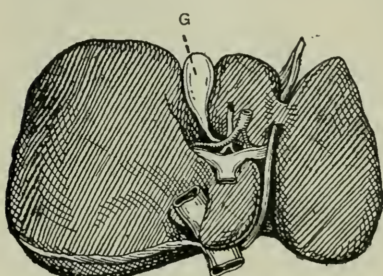
Let us now see what happens to the digested materials which have been absorbed from the food. The fat, as we have said, is mixed with the blood by being poured into a large vein in the neck. It is carried by the blood to the tissues throughout the body, and in these it is burned up, or combined with oxygen, to produce energy and heat. What is not used in this way is stored up as fatty tissue under the skin. Waste matters are produced as the fat thus performs its work and is consumed. These waste materials are carbon dioxide and water, which are carried by the blood to the lungs and thus got rid of by the body.



Fatty tissue.
Note the fat cells (dotted).

The sugar is carried by the blood to the *liver*. This organ is really a large gland, the largest in the body, and is situated on the right side underneath the lungs, from which it is separated by the large muscular mem-

brane called the diaphragm. In the liver the sugar is stored up, being changed into a new substance which we call *glycogen*, and this glycogen is given out again to the blood as it is required. The glycogen is changed back into sugar, and in the tissues it is burned up, giving energy and heat, and forming carbon dioxide and water as waste products. If an animal is being starved or insufficiently fed, the liver passes out a supply of glycogen to the tissues. It does the same when hard exercise is being taken. Animals which sleep during the winter, such as the bear or the frog, rely upon their stored-up glycogen as well as upon their fat to supply them with warmth and nourishment. Before they begin their winter sleep, the liver has a large store of glycogen; by the time that spring comes, this has all been given out to the tissues, and the liver cells have quite exhausted their store.

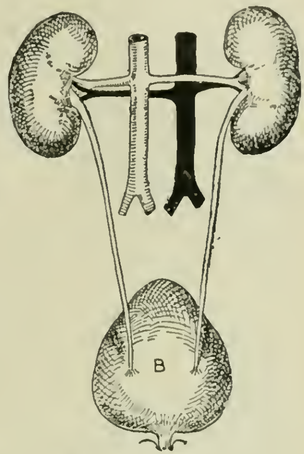


Under side of liver. Note the gall-bladder (G) *and blood-vessels.*

The liver has other functions to serve besides storing up sugar: it breaks down nitrogenous matter and prepares it for being acted on by the kidneys; it also produces a fluid called *bile*, which it pours into the intestine. Bile helps in the work of digestion, and also carries with it waste matter to be expelled from the body. When the liver is overtaxed some of this waste matter finds its way into the blood and causes discomfort or illness. A disordered liver gives rise to

such symptoms as drowsiness, headache, irritability of temper, and a feeling of depression. A sad or gloomy feeling is called "melancholy;" the word melancholy really means *black bile,* and was originally used to describe the low spirits produced by biliousness. We now use it for low spirits due to any cause, especially to disease of the brain.

We have next to see what becomes of the protein after it is absorbed. It is taken up from the intestine as a simple substance called *peptone,* and, as we have seen, it passes directly into the blood. In this way it reaches the tissues, and provides material for growth and for repair. The waste products, which are due to the breaking down of nitrogenous tissue, are very complex chemical substances. These products are removed from the blood by the kidneys, chiefly in the form of a substance called *urea.*

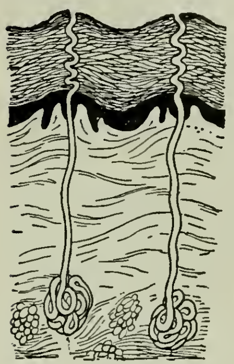


The kidneys, conveying waste matter from the blood-vessels to the bladder (B).

The *kidneys* are two in number, one towards the right and the other towards the left side of the body; and they are richly supplied with blood. The kidneys remove the waste nitrogenous matter from the blood, and they also remove from it waste mineral salts and water. From each kidney a tube conveys waste matter to the bladder, the muscular organ which expels the waste from the body. When too much food is taken, the cells of the kidneys are often overtaxed

in their attempt to get rid of the excessive waste. In hot weather, when the skin perspires freely, the amount of water passed by the kidneys is less than it is in cold weather, when the sweat glands of the skin are less active.

The *skin* has an important work to do in ridding the body of waste or used-up materials. This work is done by special groups of cells which form the *sweat glands*. They are extremely numerous, and it has been calculated that if these tiny glands were all stretched out and arranged in a straight line they would extend to a distance of eight miles! Sweat consists almost entirely of water, but there is a small amount of carbon dioxide and salt present in it. Sweat is always being formed by the sweat glands. When the amount is so small that it evaporates without wetting the skin, it is called "insensible" perspiration; it is said to be "sensible" or appreciable when it can be seen in the form of water on the skin. Over a pint of water is lost from the skin in this way every day. The sweat glands are controlled by the nervous system. A feeling of excitement often makes the skin feel damp by increasing the action of these glands.



Sweat glands in the skin. Note the spiral ducts passing to the surface.

Although the sweat is one of the means by which waste matter is removed from the body, this does not seem to be the most important function of perspiration. Its chief use seems to be to regulate the loss of heat from the body: when much sweat is produced, the

surface of the body is cooled down by the moisture being turned into vapour.

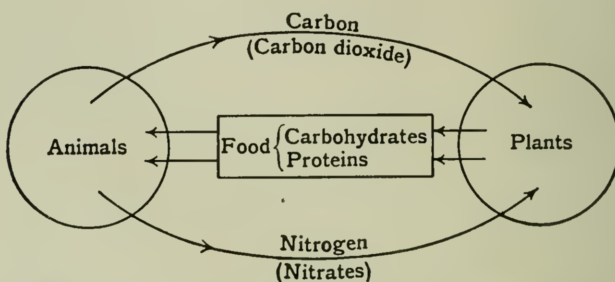
We have now considered the various ways in which the matter which enters the body in the form of food is removed as waste, after having served its purpose in building up tissues and producing energy and heat. Carbon, we have seen, leaves in the form of carbon dioxide or carbonic acid gas, chiefly by the lungs, but partly by the sweat glands. Nitrogen is removed chiefly by the action of the kidneys. Salts pass off through the action of the kidneys and also of the sweat glands. Water leaves the body by all these means—in the breath from the lungs, through the sweat glands, from the kidneys, and also by the bowel, along with the indigestible parts of the food.

It is interesting to note that these waste materials are not entirely useless; some of them, in being removed, do useful work for the body. A certain amount of heat is produced in their removal, which is of use. The impure air which comes from the lungs is utilized in producing the voice and the power of speech. The perspiration not only removes waste but regulates the heat of the body. The kidneys are supposed to have an important effect on the well-being of the body as well as serving to remove waste. Even the indigestible parts of food, if not too great in amount, are useful as "ballast," and help the intestine in its work upon the digestible parts.

Before we leave the subject of food and nourishment, we may notice how plants and animals work together in this matter, and depend upon each other for their food supply. Plants are used as food by animals, and the waste material from the animals goes to nourish and build up the plants. In this way certain

chemical substances are kept circulating between the animal and the vegetable kingdom, going from plant to animal, and back again from animal to plant.

Carbon, for example, is taken into the animal body in various forms, as fats, starches, and sugars. After being burned up or combined with oxygen in the body it forms carbon dioxide, and is breathed out from the lungs, accompanied by water vapour. Plants as well as animals breathe, but they breathe in carbon dioxide



Carbon and nitrogen circulate between the world of plants and the world of animals.

and water vapour. Plants, therefore, take in as nourishment what animals reject as waste. The plants build these substances into their tissues, storing up the carbon, oxygen, and hydrogen in the form of starch, sugar, and other materials. Man and other animals, again, feed on the plants, and get energy and heat from their starch and sugar; and when these have been thus reduced to carbon dioxide and water vapour again, they will once more be taken up by the plant world to begin a new cycle.

Let us now see what happens to nitrogen, the chief material used in building up the tissues of the body, which is supplied to it in the form of protein. The

waste nitrogen, as we have seen, is removed from the blood by means of the kidneys. This waste matter is called urea, and it finds its way back to the soil. There it is acted upon by certain kinds of microbes, or fermented, as we may say, and is broken up into simpler substances.

We have seen that the human body cannot take up pure nitrogen; it can only make use of it when in the form of protein. For plants also there is only one form in which nitrogen is available, and that is in the form of *nitrates*. The conversion of nitrogen into nitrates is the work of these small organisms in the soil. These substances are then laid hold of by the roots of plants, and are taken up into their substance, along with a supply of water. In the plant the nitrogen is built up into vegetable protein, such as we find in peas and in wheat and other grains. This vegetable protein may then become the food of man directly. It may be eaten by animals, such as sheep or bullocks, and formed into animal proteins, and thus it becomes human food indirectly. So the nitrogen goes on circulating from animals, through the soil and its small organisms to food plants, and from these plants back to man, either directly or through the medium of the animals whose flesh is used as part of our diet.

CHAPTER X

THE TEETH

A BUSINESS man once advertised for two apprentices, a boy and a girl, for different departments of his business. A large number of boys and girls applied, and a few of those who seemed to be the best on the list were selected and sent in to the manager. All had good certificates from their schools; they were neatly dressed and had good manners. How was the manager to decide which boy and which girl to employ? He decided to take those who had the best teeth. Only one of the boys and one of the girls had a good set; their teeth were white and regular, and showed no signs of decay. In most of the others some teeth were missing, or the teeth which they had were yellow in colour, and had dark spots here and there which showed the presence of decay.

Why do you suppose the manager chose the boy and the girl with the best teeth? One reason was that he wished to have apprentices who took some interest and pride in their personal appearance. He knew that boys and girls who are careless regarding their teeth are likely to be careless in other things as well. But there was another reason for his choice. Young people who have bad teeth are likely .to suffer from toothache, indigestion, and bloodlessness, and may often

be unable to attend to their work on account of their ailments.

During the great war in South Africa, when so many Canadians went to fight for the Empire there, one young man was greatly disappointed because the medical officers would not admit him into the army. The reason was that his teeth were not good. "But I do not want to eat the enemy," he protested. He was refused, however, and a great many others were refused for the same reason. Every year a large number of young men who want to be soldiers are unable to enter the army because they have bad teeth. Good teeth are necessary in order that the food may be properly chewed and prepared for being digested. Otherwise we do not get the nourishment from our food which we require. This is specially necessary for soldiers. They have often to put up with coarse and poorly-cooked food when they are in the field, and yet they must be well nourished and strong. A man with defective teeth cannot keep fit and efficient as a soldier.

A good set of teeth: a picture of a Spanish boy by Murillo.

All trouble of this kind can be prevented if we attend to the teeth in early life. In order to understand how this should be done, we must know what the teeth are, how they grow, what enemies attack them, and how they can be protected against these.

For the first seven or eight months of its life a baby has no teeth that we can see. There are teeth hidden

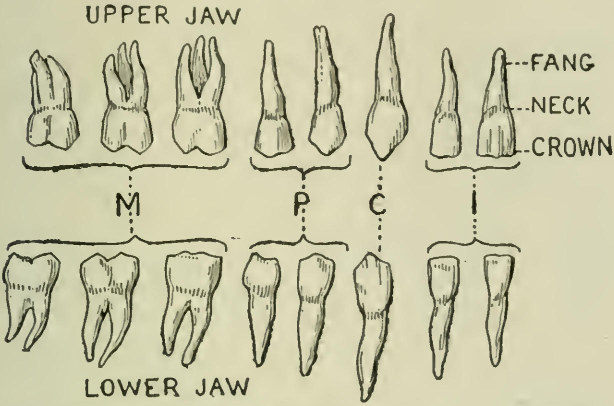
in the gums, however, and as the baby grows older they begin to appear one by one, cutting their way through the skin. By the time that two and a half years have passed they have all come through, and the child has twenty teeth.

A baby's teeth are small and white. If you look at them you will see that they are not all of the same shape. The four front teeth in each jaw are called *incisors.* They have a sharp edge for biting or nibbling with. Next to these, on each side, comes a sharp pointed tooth; if it were big enough it would be like a dog's tooth, and we call it a *canine* or dog tooth. It is useful for tearing through any tough substance such as meat. After the canine teeth come the grinding teeth or *molars.* They are broad and flat on the top, and are meant for crushing and grinding down the food. Each kind of tooth has its own work to do, and if they are to be strong and healthy we must see that the child's food is such as to give them plenty of work of the right kind.

The first set of teeth are called *milk teeth* or temporary teeth. They last only for a few years, until the permanent teeth grow. Some people think that as these teeth are going to come out soon, there is no need to trouble about cleaning them. This is a great mistake. A child's teeth should be cared for from the time when the first tooth appears. We could hardly brush a baby's first tooth with an ordinary toothbrush, but it should be wiped with a bit of clean soft rag, which is afterwards burnt. Quite young children, however, should have their teeth regularly brushed with a soft brush, and they soon learn to do this for themselves.

When a child is six or seven years old the perma-

nent teeth begin to appear. There is one very important thing to notice about the appearance of these: the first new permanent tooth to appear is the one which comes *behind* all the baby teeth, on each side of each jaw. Very few people seem to know this, and these four teeth are often allowed to decay through want of care. But if these teeth become diseased and have



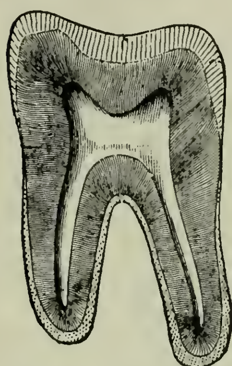
The teeth in one side of the upper and the lower jaw, showing the incisors (I), *canines* (C), *and grinding teeth*—(P), *pre-molars or bicuspid, and* (M), *molars*).

to be extracted, no others will ever come in their place.

After these new teeth have appeared above the gums, the front teeth, or incisors, fall out, and new and stronger ones come in their place. Gradually all the milk teeth come out and are replaced by permanent ones; and some additional new teeth also appear at the back of each row, so that a child of twelve or thirteen years of age has twenty-eight teeth. Four more teeth appear much later—usually about the eighteenth year —and on this account they are called the "wisdom

teeth." The full set of teeth of a grown-up person thus numbers thirty-two—sixteen in each jaw.

From this short description you see that the teeth come in a definite order and at certain definite ages. So regular is the time of their appearance that one can tell the age of a child by looking at his teeth.

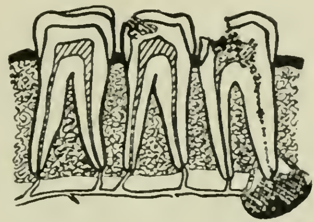


A molar tooth in section, showing the hard outer layers and the inner cavity.

It is the same with the lower animals. That is how a horse-dealer knows the age of a horse. You may have heard the old proverb, "Do not look a gift horse in the mouth." Have you ever wondered what that means? The literal meaning is that if you receive a present of a horse, you should not try to find out whether it is young or old — that is, whether it is worth much money or not. The proverb really tells us that we should not judge the worth of a present by its money value.

If you were to stop the first hundred grown-up people you meet, and ask them how many teeth they have, you would be surprised to find how few have the whole set of thirty-two complete. Doctors have sometimes to examine the teeth of people who apply for certain situations, and one doctor who has examined hundreds of young men and women for this purpose tells us that he often finds as many as ninety-nine out of every hundred with at least one tooth missing or decayed; a large number have several teeth missing. How is it that so many people lose some of their teeth?

To understand this, you must first learn something about the structure of a tooth. Each tooth consists of three parts—the *crown*, which is the part above the gum; the *neck*, where it passes into the gum; and the *fang*, which is the part fixed in the gum. Running up the inside of the tooth is a small canal containing blood-vessels and nerves. The tooth itself is composed of a hard substance called *dentine*, and the outside of it is covered with the *enamel*, a white substance which is much harder even than bone.



How teeth decay. The first tooth is sound, the second has a hollow in the crown, and in the third decay has reached the nerve, and a painful abscess formed in the gum.

The function of the teeth is to cut up and grind the food into small pieces, and thus to prepare it for digestion before it passes into the stomach. Particles of the food often get into the spaces between the teeth and remain there. A great number of small organisms or germs find their way into the mouth, and they lodge in these food particles and cause them to ferment or decay. When this takes place, certain chemical substances called *acids* are produced. These acids corrode the teeth, burning or eating their way through the enamel and then through the dentine. When at last they reach the nerve of the tooth, a severe pain is felt which we call *toothache*, and the tooth may have to be extracted, or it may crumble away.

When a hollow has thus been made in one tooth, the germs lodge there and increase in numbers. They then spread to the other teeth, and so the sound teeth

are infected with decay. The condition of the mouth gets worse and worse until all the teeth may be ruined. This may seem a dreadful picture, but it is only what is happening to thousands of people who do not take care of their teeth.

The teeth of savage peoples are generally better than ours. Their food is usually harder and coarser, and the chewing of such food cleans the teeth. Children, and grown-up people too, in civilized countries eat soft food which does not need to be chewed, and so the teeth are not sufficiently used. Soft food is also more apt to remain between the teeth than hard food.

Now that you know how decay is produced in the teeth, you will be able to understand the reason for the simple rules which ought to be observed in order to protect them from harm and to keep them in good condition.

The first important rule is this: Do not eat soft food only. Toast, the crust of bread, and apples are excellent for the teeth. They give exercise in chewing, and they also clean the teeth.

The second rule to be observed is this: Before going to bed, and again after rising in the morning, brush your teeth with lukewarm water, using also tooth powder or paste. Expensive tooth powders are not necessary; many simple and cheap kinds are quite as good. These powders or pastes contain substances which destroy the acids formed by the decay of food particles, and prevent their corroding the teeth. It is not enough to brush *across* the teeth; the upper teeth should also be brushed downwards and the lower teeth upwards from the gum. The inner sides of the teeth and the crown of the grinding teeth must also be carefully cleaned.

It is most important that the teeth should be cleaned at night, as otherwise particles of food will remain between the teeth during the long hours of sleep. Sugar is bad for the teeth because a very

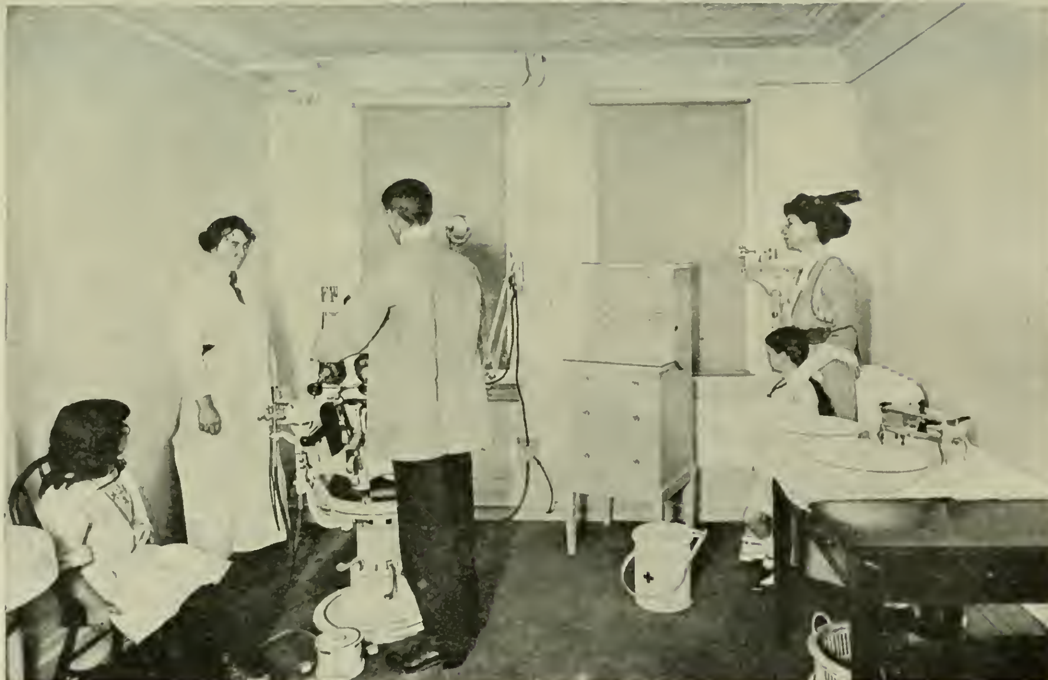
"*Brush your teeth*" (p. 122)—*tooth-brush drill at the "Forest School," Toronto.*

destructive acid is produced from it. Sweets should, therefore, never be eaten at night. Another common practice which is bad for the teeth is to eat bread soaked in milk for supper. This makes a very good supper for children, but for the sake of their teeth it should be followed by a piece of bread crust or toast.

Sometimes the teeth overlap in such a way that it is impossible to clean the space between them with a brush. In this case they can be cleaned by passing a thread between them. A special kind of thread, called "dental silk floss," is made for this purpose.

By following these rules you will keep your teeth clean, and they will not be likely to decay readily. But whenever a dark speck appears on one of them, you should visit a dentist. He will remove the decayed part and fill the cavity with some hard substance, so that the decay may spread no farther. It is a wise plan to visit a dentist regularly every six months. He can then examine each tooth carefully, and he will often discover small points of decay of which you did not know. If you do this, you need never suffer from toothache. Any decay will be stopped long before the tooth has been eaten through and the nerve affected. When decay is attended to before it has gone far, the stopping of a tooth is not painful.

You can now see that the teeth cannot be kept clean and sound unless you take some trouble. But surely it is well worth the trouble when you consider the advantages. You escape the pain of toothache, you avoid such troubles as indigestion and bloodlessness, which are due to the want of good teeth to chew with, and you save a great deal of expense in many ways. At the same time you make yourself much more attractive in appearance, for no amount of care in dress will make up for the disagreeable appearance of badly-kept teeth.



"It is a wise plan to visit a dentist regularly" (p. 124). *Dental room at Alexandra School, Toronto.*

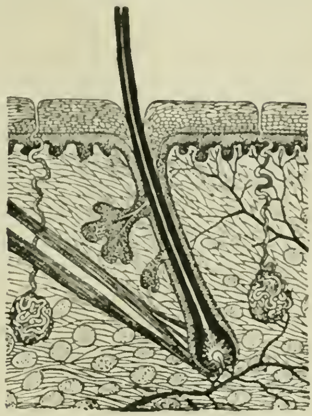
CHAPTER XI

THE SKIN

All animals and plants have some kind of outside covering to protect the parts within. These coverings differ much in appearance, and are known by different names: for example, we speak of the human *skin*, of the *hide* of a bullock, of the *fur* of a bear, and of the *bark* of a tree. But when we examine the different kinds of animal coverings by the help of a magnifying glass or a microscope, we find that they are liker one another than we may have supposed. The surface of each is composed of a large number of tiny scales, closely packed together, and on each there are long hairs growing outwards. The bear's fur differs from the human skin in having those hairs much longer and more numerous, while the hide is very much thicker and stronger. The lower animals require more natural protection than man does, for man wears clothes as an additional protection, and can change this covering to suit the weather.

Let us look at a drawing of the skin as seen through the microscope. We see that it is composed of tiny cells, just as a wall is built up of bricks, and on the surface these cells are flattened so as to form scales. Here and there we see tiny openings on the surface; these are the mouths of little channels which come

from the sweat glands. When our body gets hot, either because the weather is warm or because we have been doing some active work, small watery drops of sweat or perspiration begin to appear at these openings. We have already spoken of the body as a steam-engine, and we have seen that it must throw off waste material just as the engine must get rid of the waste steam from the cylinder and the ashes from the furnace. You already know that sweat is one of the waste materials of the body;



Section of the skin. Note the surface cells, the sweat glands, and the root of a hair, with muscle fibres which make the hair stand erect.

and by means of these channels or pores in the skin it is carried to the surface of the body.

The skin is thus not only a protective covering, but is also an organ which gets rid of waste matter. One writer has said that it is at once a waterproof and a drainage system. But the skin serves a third purpose, which we must next consider.

"*He cools himself by opening his mouth*" (p. 128).

Have you noticed that when a dog is hot with running about he keeps his mouth open and lets his tongue hang out? He does this in order to cool himself. The moisture from his mouth evaporates, and

evaporation from any surface cools it down, as you can prove for yourself by wetting your hand and letting the air dry it. A dog has no sweat glands in his skin such as we have, so he cools himself by opening his mouth. But when we run about or play an active game, our skin becomes wet with perspiration, and the evaporation of this by the air helps to make us cool.

There is another way in which the skin helps to cool the body when it is too hot. When you are heated with any exercise, your face becomes red and flushed. In the skin there are many small blood-vessels, or tubes through which the blood flows. When these vessels are full of blood, the skin looks red; when there is little blood in them it looks pale. So when your face is hot and flushed, there is much blood flowing through those tiny blood-vessels of the skin, and this blood is cooled down by the outside air. When you stop playing an active game and sit down to rest, you ought always to put on some extra garment, such as a woollen sweater, until you cool down. If this is not done, the body will lose too much heat by the evaporation from the surface of the skin and the rush of blood through its blood-vessels, and you may catch a severe chill.

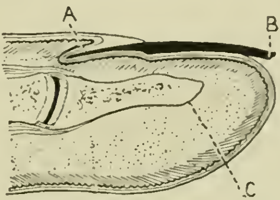
The skin has yet another function to perform: it contains the nerves by means of which we *feel*. When we want to know whether a thing is hard or soft, sharp or blunt, hot or cold, we place our hand upon it or touch it. The nerves in the skin then send to the brain messages telling what the object feels like. We learn so much by means of our eyes that we are apt to forget how much of our knowledge of things comes from the sense of touch. A blind man, however, can find out nearly as much about things by feeling them

as we can do by seeing them, and it almost seems as if some blind people could *see* with their fingers.

The skin is not alike on all parts of the body. Have you ever noticed the little ridges which curve round in a curious pattern on the front part of the finger tips?

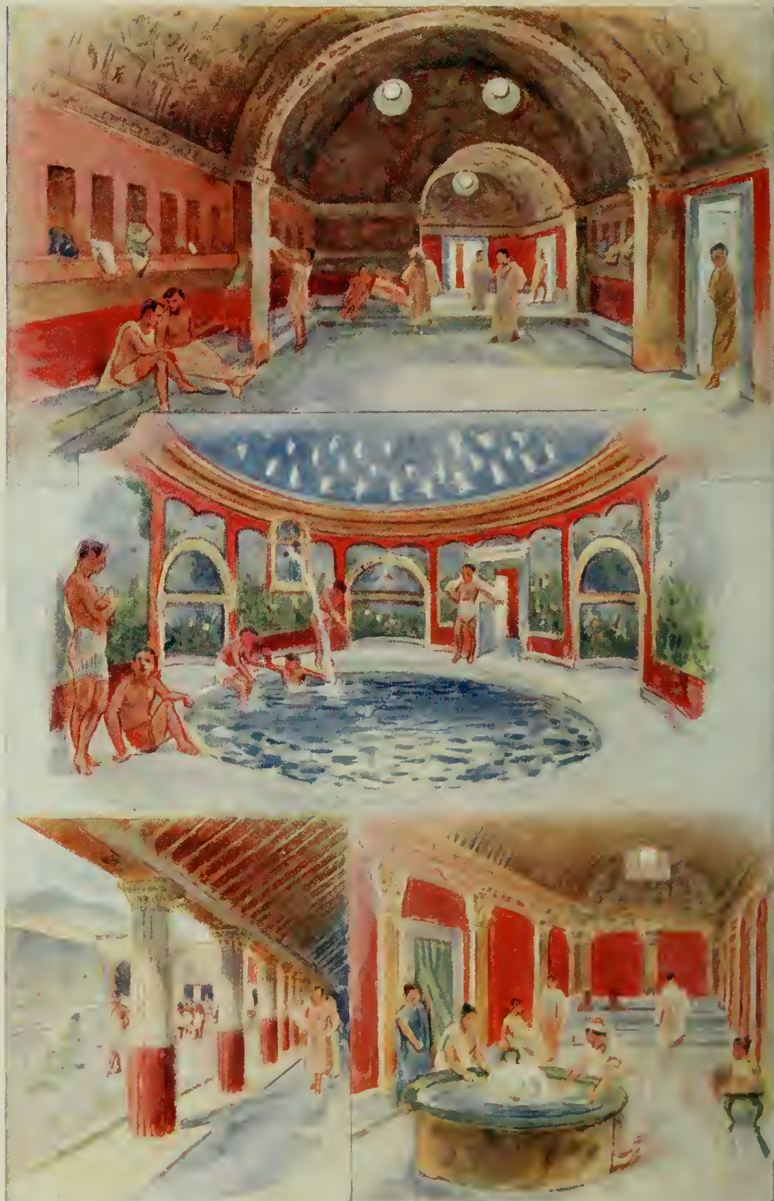
Examples of finger-prints.

The curved pattern which these ridges form remains the same all through our life, but no two persons have exactly the same pattern. When a man is imprisoned for some crime, impressions are taken of his finger-tips by the prison officers. If the man is arrested afterwards, no matter how much his appearance may have changed, or by what name he may call himself, the officers can always recognize him by examining his finger-prints.



Section of a finger-tip, showing the nail growing out from its root. Note (A) *the root,* (B) *the growing edge of the nail; and* (C) *the bone of the finger.*

From some parts of the skin other structures grow out to give additional protection to the body. Small *hairs* are found on most parts of the skin, but on the scalp there is an abundant growth of hair to protect the head. Each hair grows from a small projection deep down in a pit in the skin. When a hair is broken off or is cut short it quickly grows again. Sometimes, however, the hair is attacked by a kind of mould or



Roman Baths at Pompeii (restored).

The ancient Romans paid great attention to cleanliness, and their public baths were favourite places of resort. This picture shows parts of the baths at Pompeii as they looked before the destruction of the city—(1) the waiting-room; (2) the cold plunge bath; (3) the courtyard; (4) the hot bath.

fungus, and becomes diseased. It then falls off and does not grow again, so that baldness is produced.

The points of the fingers and toes are protected by the *nails.* A nail grows out of a deep fold in the skin, and is really a portion of the skin which has become hard in order to give protection to the parts which are specially exposed to hurt. Some animals are protected by other kinds of outgrowths of the skin. Examples of these are the horns of a cow, the antlers of a deer, the feathers of a bird, and the scales of a fish or a snake. The teeth are also a specially hard growth formed in a fold of the skin.

Horns are an outgrowth of the skin. (A South African antelope.)

The skin, then, as we have seen, has four different duties to perform. These are: (1) to protect the body; (2) to get rid of waste matter; (3) to control the heat of the body; and (4) to receive the messages of touch. It is necessary to keep this important organ of the body in good condition, and the best way of doing so is by attention to cleanliness. The skin gets dirty very readily. Dust and germs of disease settle upon it. The surface scales become loose by rubbing. The perspiration dries, and leaves some waste matter upon it. A greasy substance which is found at the roots of the hairs makes the skin unpleasant and grimy.

To allow the skin to remain dirty is a sure sign that a person is wanting in self-respect, and such a person cannot win the respect of others. But dirt is not merely disagreeable; it actually injures health, by

interfering with the work of the skin. Careful washing is necessary in order to remove the dust and waste matter from the surface, to cleanse the openings for the flow of perspiration, and to keep the blood-vessels in an active condition, so that they can adjust themselves easily to changes of heat and cold.

There are very few young boys or girls who really like to wash. Cleanliness is a habit which must be learned. It may be hard and unpleasant at first, but children will find that it is worth while learning. It gives pleasure to other people and wins their respect, and by-and-by the habit of cleanliness becomes pleasant in itself.

Cold water and hot do not act upon the skin in quite the same way. Washing with hot water and soap is necessary to remove the dust and grease which adhere to the skin. Cold water is less useful for cleansing, but it has a more bracing effect upon the body. Both hot and cold baths are necessary if we are to keep the skin in the best condition. The face should be washed at least once every day in warm water. The hands are being constantly soiled, and they must be frequently washed, especially before a meal. If food is taken with dirty hands, all kinds of impurities may find their way into the body along with the food. Nothing could be more unpleasant than the idea of eating food which is not quite clean.

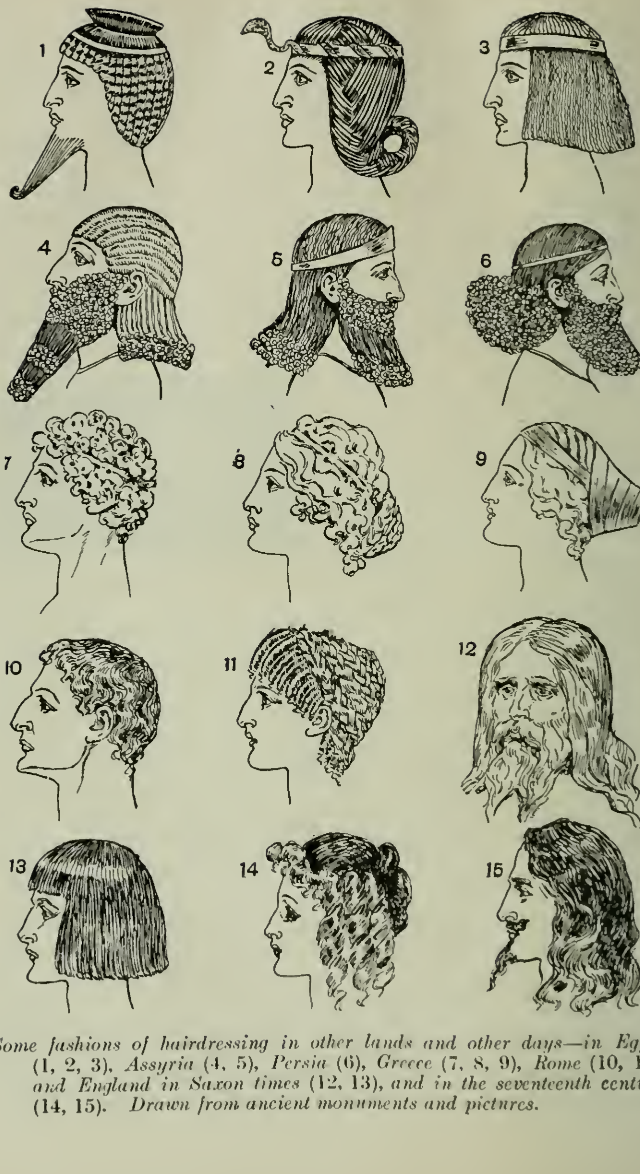
The whole body should be thoroughly washed in warm water at least once a week. When children reach the age of nine or ten, they should begin to take a daily cold bath. This is best taken in the morning, just after getting out of bed. All that is needed is to plunge into cold water and then to dry the body by vigorous rubbing with a rough towel. If one is in good health, this

gives a pleasant feeling of active well-being, and is an excellent and healthful way of beginning the day. Baths can be most easily taken where there is a comfortable bathroom in the house, but it is a mistake to suppose that one cannot keep clean without a fine bathroom. Both hot and cold baths can be quite easily taken by sponging the body, and in this way the skin can be kept perfectly clean.

Certain parts of the body require special attention—the teeth, the nails, and the hair. The teeth are so important that we have already given them a chapter to themselves. Look at your hand, and you will see that the nails are attached to the finger except at the end, where the edge projects a little. When dirt gathers under this edge, it is not removed by the ordinary washing of the hand. It forms a black line which makes the hand look untidy and disagreeable. This must be removed by a brush, or by a blunt point which will not injure the tender skin under the nail.

A Chinese mandarin's finger-nails.

Nails, like hair, are always growing in length, and they require to be regularly pared and trimmed. In some Eastern countries, rich people allow their finger-nails to grow long, in order to show that they do not need to work with their hands. In China, a mandarin sometimes has finger-nails like the claws of a bird, and wears silver sheaths to protect them. We do not admire such marks of superiority. Long and badly-trimmed nails are unsightly, and they collect dust and germs which may be very harmful. The nails should be trimmed by paring. Some young people have a bad



Some fashions of hairdressing in other lands and other days—in Egypt (1, 2, 3), *Assyria* (4, 5), *Persia* (6), *Greece* (7, 8, 9), *Rome* (10, 11), *and England in Saxon times* (12, 13), *and in the seventeenth century* (14, 15). *Drawn from ancient monuments and pictures.*

habit of biting the nails. This is a disgusting and uncleanly habit, as the refuse matter which gathers under the nails is conveyed direct to the mouth. The skin round the top of the nail should be carefully pushed back when the nails are being trimmed or the hands washed, as it sometimes grows too far down on the nail and becomes ragged and unsightly. Well-kept nails are an ornament as well as a protection to the fingers.

The *hair* requires a good deal of attention, but it is well worth our while giving it the care it requires. Well-kept hair counts for much in the appearance of any one, especially of a girl. People of different countries dress their hair in many different ways, but they are all agreed in regarding beautiful hair as a great adornment. Hair differs much in colour, according to the amount of pigment or colouring matter which is contained in the shaft of the individual hairs. Gray or white hair is due to bubbles of air collecting inside the hair.

The hair should be brushed vigorously night and morning. This is useful in two ways: it cleans the hair by removing the dust and the loosened scales of the skin which have gathered among the hairs, and it also causes an increased flow of blood through the small blood-vessels of the scalp, and so brings plenty of nourishment to the roots of the hairs and causes them to grow well. A girl's hair, which is worn long, requires much more care than a boy's short hair. When a girl is old enough to look after her own hair, she should make up her mind never to go to bed without brushing it well. Once this good habit is formed, it would feel as strange and uncomfortable to go to bed with unbrushed hair as it would to go to bed with one's day clothes on.

Brushing and combing are not all that is needed, however. The hair must be regularly washed also. This is a much more easy matter for a boy than it is for a girl. Children's hair should be washed once a week, and should be carefully dried. A bad cold may be the result of going to bed with damp hair. Many kinds of hair-wash are sold, and some of them are quite safe and pleasant to use, but there is really no need for anything more than good soap and plenty of water. In some schools the girls are required to wear their hair in plaits. It would be well, perhaps, if all schoolgirls wore their hair in this fashion; the hair is kept free from tangles, and gathers less dust, and is more easily kept clean than when hanging loose. Wearing the hair in two plaits down the back is a pretty as well as a cleanly fashion.

CHAPTER XII

THE BLOOD

If you ever visit the University of Cambridge, in England, you may see in one of its colleges a portrait which is greatly prized. This is the portrait of William Harvey. Perhaps you have never heard his name before. Yet he will always be remembered by those who study the human body, for it was he who discovered the circulation of the blood. None of the learned men of old times knew that the blood flows through the body; more than one had thought this possible, but it is only some three hundred years since the fact was clearly proved. By studying the bodies of animals, Harvey found that the blood passes from the heart to all parts of the body, and that it flows back to the heart again. The blood keeps up a continual circulation through the body. On its outward journey it is pure; on its return journey it is impure.

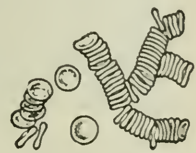
At first few people would believe that Harvey was right in what he said. Many of his patients refused to have him as their doctor any more. But gradually people came to believe in his views, and to see that he had made a wonderful discovery. He received the honour of being appointed Physician to the King, Charles I. Harvey's discovery of the circulation of the blood is really one of the greatest advances ever made in our

knowledge of the human body. We must now see what the blood is, and later we will study the way in which it circulates through the body.

The blood has always been regarded as the most important thing in the body, and in figurative expressions it is often spoken of as being our life. We speak of a man being ready to "shed his blood" for his country—that is, to give up for it all that he values, even life itself. We say "our blood runs cold" when we are terrified or shocked by something, and that "our blood boils" when we are very angry and excited. People of the same tribe or race are said to be "of one blood." Among some peoples the symbol of the closest friendship is the mixing of a few drops of blood drawn from two friends, who then become more than brothers. In many of the symbolic rites and superstitions of people, the blood is regarded as being something sacred, and in a special way connected with life.

If you were asked to tell what you know about the blood, you would begin by saying that it is red. It is of so rich and deep a colour that we use it as a kind of standard of redness. We call a thing "blood-red" when we wish to say that it is intensely and vividly red, just as we use the colour of the sky as a standard of blueness, and describe certain flowers as "sky-blue," because their colour is bright and pure. You also know that blood is a liquid. A little boy of three and a half years old, who had cut his finger for the first time, watched the blood oozing out of the cut, and then called out, "Mother, it's red juice!" These two words expressed the two facts about blood which we have just mentioned, and showed very good powers of observation in so young a child.

Every one has had a cut or a scratch at one time or another, and must have noticed that when the outer skin is pierced through a little blood oozes out. In a small cut the blood stops flowing after a very short time. If bleeding went on, all the blood in the body would escape through even a small opening, but this does not happen unless some large blood-vessel is cut. There must be something, then, which stops the flow. If a kettle or a pitcher leaks, you stop up the hole with solder. Bleeding is stopped in the same way, but it is the blood itself which provides the solder. When blood is exposed to the air it forms into a clot like jelly, and this clot closes up the wound until it heals and the skin grows together again.



Clusters of red cells in the blood.

So far we have only considered the blood as we see it with our unaided eyes; it is a red fluid which clots when it escapes from the blood-vessel or tube through which it flows. But by the help of the microscope we can see many wonderful things in a single drop of blood—things of which our eyes give us not even a hint. Under the microscope we see that the fluid is not red; it is almost colourless. In this clear fluid float thousands and thousands of tiny cells, and these are of two kinds—red cells and white cells. The usual name for these is *corpuscles,* which means very small bodies.

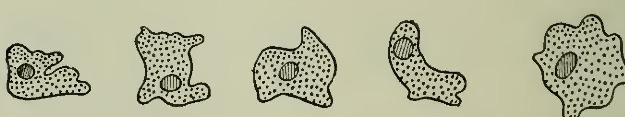
The red corpuscles are by far the more numerous, there being about five hundred of them present for every white corpuscle. They are circular in form, but not quite flat on the sides, being thinner in the middle than round the edge. They get their red colour

from a substance called *hæmoglobin* which they contain. This substance has the power of seizing upon oxygen when it is present, and it is thus that oxygen is absorbed by the blood in the lungs. It is interesting to know that the red corpuscles differ in shape and size in the blood of different animals, and by this

"The red corpuscles differ in shape and size in the blood of different animals."

one can sometimes tell whether a bloodstain has been caused by human blood or not.

The white corpuscles, as we have said, are much fewer in number than the red. They are also much larger. They are usually rounded in form, but they



"The white corpuscles have a curious power of changing their shape."

have a curious power of changing their shape, pushing out a projection here and there, and thus moving about or swimming through the fluid of the blood. There is a very simple type of animal called an *amœba* which moves in the same way, and this kind of movement is called *amœboid*, or "amœba-like."

Each of these parts of the blood has its own special work to do, and we must now consider what that work

is. You must first recall some things which you were told about the digestion of food. The nourishing part of the food is taken up by small tubes in the inner lining of the intestine, and flows along these and other tubes till it is mixed with the blood. In the tissues of the body the blood flows through small hair-like blood-vessels called *capillaries*, and the walls of these small vessels are so thin that the nourishing material passes through them into the various tissues. It is in this way that the muscle and other tissues get their food supply. The nourishing fluid, or *lymph* as it is called, not only gives up its nourishment to the tissues, but it also collects from them the waste material which they need to get rid of and carries this back to the blood again.

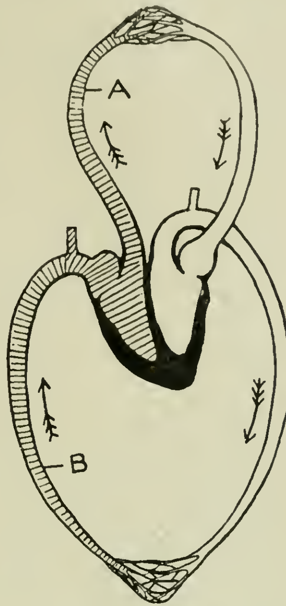


Diagram of the circulation of the blood from the heart through the lungs (A) *and through the body* (B). *The shading indicates impure blood.*

The *red corpuscles* of the blood have a different work to do. They are charged with the coloured matter we have mentioned, hæmoglobin, and this, as we have said, stores up a supply of oxygen while it is passing through the lungs. The business of the red corpuscles, then, is to carry this precious load of life-giving oxygen all through the body. As the blood flows along the small capillaries, the surrounding tissues

seem to seize hungrily upon the oxygen which it carries. When the corpuscles are charged with oxygen, they are bright red in colour. As they lose their oxygen they become darker and take on a purple tinge. If you allow your hand to hang down for a little while so as to check the circulation, you can see the dark colour of the impure blood showing through the small veins on the back of the hand and the arm.

Now we come to consider the work of the *white corpuscles* or cells. It is only in recent years that we have found out much about these, but the facts which we already know make up a story which reads like a fairy-tale. These facts make us think of the body as a great city, and the white cells as an army of soldiers who are ever on the watch against such enemies as venture within its walls. They may also be regarded as the scavengers, who seek out and remove any waste or hurtful material. The white cells are always on sentry duty throughout the body. They float along in the blood stream, and wherever they are required they assemble quickly in vast numbers. But they are not confined to the blood-vessels; they can pass through the walls of these vessels and into the substance of any tissue where they are needed.

Sometimes the body is invaded by disease germs. Then the white cells gather round these germs and wage war against them. If possible, they destroy the germs by eating them up or absorbing them into their own substance. Sometimes they carry on the fight in a different way: they produce a poisonous substance which kills the disease germs. The germs defend themselves by making a poison which kills the white cells. If many disease germs have entered the body,

there is a serious battle. As the white cells are killed, others come up and take their place, just as soldiers in the reserve advance to fill the places of those in the firing line who are wounded or killed. In the end, victory goes to the stronger side. If the germs win, the city surrenders and the body dies.

When the victory goes to the white cells, they often win so splendidly that the body is safe from attacks by that particular kind of germ for a long time, or even for the whole of its life. The poison made by the white cells to kill the disease germs is strong enough to keep those germs from ever getting a foothold within the city again. Thus a person who has had measles or scarlet fever very rarely has a second attack; he is said to be "immune" from the disease, or safe from its influence, ever after.

Victory in this strange warfare often depends upon the white cells being able to poison the germs quickly, and physicians have now discovered that they can help the cells in this work. This is done in a very serious disease, called diphtheria, by introducing into the body a substance called *antitoxin*. *Toxin* is a name which means a kind of poison, and *antitoxin* means something which hinders the poison from acting. This antitoxin is administered for the purpose of preventing the action of the poison made in the body by the diphtheria germs. It gives much help to the white cells that are engaged in the same work, and by this treatment hundreds of people have recovered from diphtheria, who would otherwise have died. The way in which this antitoxin is obtained is very interesting. A horse is infected with diphtheria, and after its white cells have had time to produce the substance which poisons the germs, some of the blood is drawn off,

which is then so full of this substance that it is called antitoxin. When we get to know more about the germs which produce other diseases, many more kinds of antitoxin will, no doubt, be made to combat them, and many lives will thus be saved.

But the white cells, as we have said, perform other duties as well as those of soldiers. They help in the process of healing a wound. When any tissue has been hurt, the white cells make their way out of the blood and reach the injured part. There they eat up and clear away any parts of the tissue that are dead, and so the process of healing is able to go on.

The white cells also remove dust and other impurities which find their way into the body. In cities where there is much factory smoke in the air, the cells are kept busy removing such specks of dust as make their way into the lungs. Wherever any substance enters the body which should not be there, these faithful warriors attempt to get rid of it, and they will either do this or perish in the attempt. So you see we are quite right in describing the white corpuscles of the blood as soldiers, doing sentry duty through the body and fighting its enemies, or as scavengers, keeping the tissues clean. They go at once wherever they are required, and they do this without waiting for orders from us, and indeed without our knowing anything about it.

It may be hard to believe that all this really goes on in the body of each of us, but the movements and the work of the white cells can actually be seen through the microscope. More than this: the warfare between these cells and the germs of disease has actually been photographed and shown by means of the cinematograph on an enormously enlarged scale.

We cannot give orders to our white cells, but we can keep them fit for their work. Everything which helps to keep us in good health improves the fighting power of these cells. Abundance of fresh air, by day and by night, is one of the best means of keeping the white cells fit for duty and ready for any call that may be made upon them. Care in the use of food and drink is also important, especially as regards alcohol. It would be very foolish in a general commanding an army to do anything which would make his soldiers less able to fight, but that is what every one does who indulges in alcohol. As we have learned in an earlier lesson, alcohol weakens the power of the white cells, and so makes it more easy for disease germs to fight and conquer them.

CHAPTER XIII

THE CIRCULATION

A LITTLE girl once had her arm hurt, and was taken to a children's hospital. The doctor there attended to the injury, and bandaged the arm across her chest in order to keep the parts from moving while it was healing. The girl was then taken home, but about two hours later she was back again at the hospital. Her mother said that she had never stopped crying since her arm had been tied up across her chest. The doctor tried to find out what was wrong, and at last he discovered it. The little girl thought there was something alive inside the bandage. She felt something that fluttered and moved there, and it made her afraid. Then the doctor understood what was the matter.

Have you guessed what was troubling the child? What was it that seemed to flutter inside the bandage? It was her heart that she felt go throb, throb, throb under the arm which was lying across her chest. The more excited she became, the more her heart throbbed and fluttered. The doctor soon put things right. The bandage was removed, so that the child could see that there was nothing inside it. A big soft pad of cotton wool was then put between the beating heart and the arm, in order that its movement might not be felt; the bandage was put back into its place again, and the child went off quite happy and contented.

"We can brace up and exercise the muscles of the arteries by taking cold baths" (p. 157).

Lay your hand on the left side of your chest, and you will easily find the part that flutters and throbs. This throbbing is the beating of the heart. The heart is a living pump which sends the blood all through the body. The blood returns to the heart again, thus making a complete circuit, so the flow of blood through

In a children's hospital.

the body is called the *circulation*. There is really a double circulation, as we shall see, and each drop of blood in the body passes first through the one circle and then through the other.

The heart is a hollow muscular organ lying in the chest, and towards the left side. It is really a double organ; we might say that there are two hearts, a left and a right, but these are joined together

and work together. The left heart is the stronger, and has thicker muscles; its work is to send the blood all through the body. The blood returns to the heart, as we have said, but it returns to the right heart, and is sent by it to the lungs to be purified. Then it comes back to the left heart, to be sent on another journey through the body.

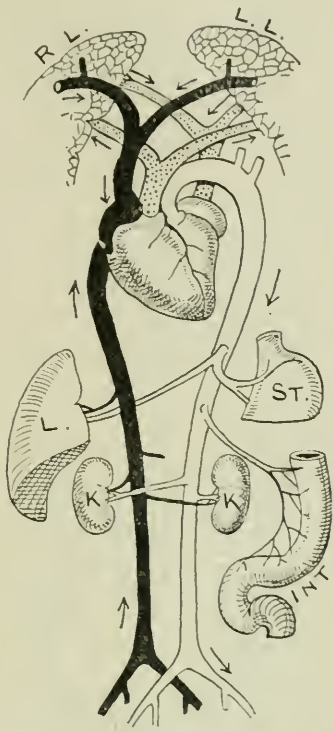


Diagram showing the main blood-vessels from the heart to the right and left lung (R.L. *and* L.L.) *and to the lower part of the body—the stomach* (ST), *liver* (L), *kidneys* (K), *and intestine* (Int).

Each half of the heart is a hollow bag with thick walls composed of muscle. When this muscle contracts, the blood is squeezed out of the bag, just as you might squeeze water out of a sponge, or out of a rubber bag, by closing your hand on it. Then the muscles relax, and the bag fills with blood again.

The heart muscles contract just as the muscles of your hand or your arm do, but there is a difference in their way of resting. The arm muscles rest by being free from work for a while, and especially during the night. The heart cannot rest in this way, as the body must be kept supplied with blood even during sleep. So the heart muscles snatch a moment's rest between each two con-

tractions or beats, and this is the only rest they need. They have not always equally hard work, however;

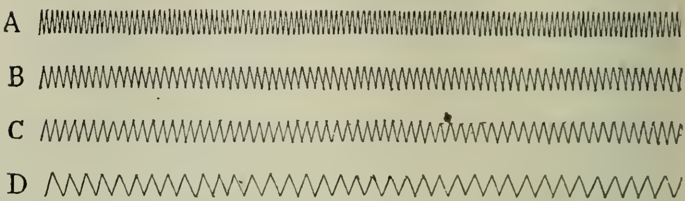
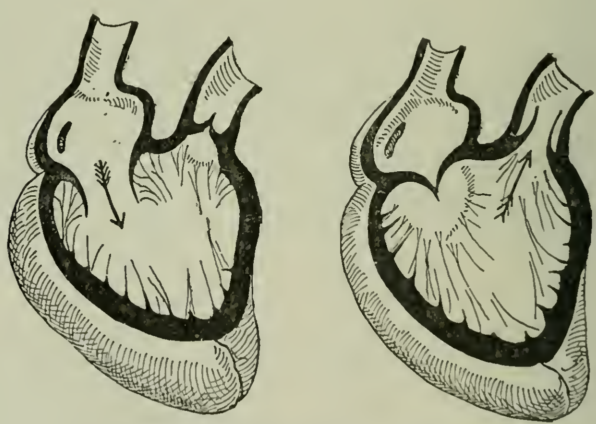


Diagram showing different rates of heart beat per minute in (A) *a baby*—130; (B) *a child of eight or nine*—90; (C) *a grown-up person*—70; *and* (D) *Napoleon*—40.

they have less to do when you are asleep in bed than when you are running about or playing some active game.

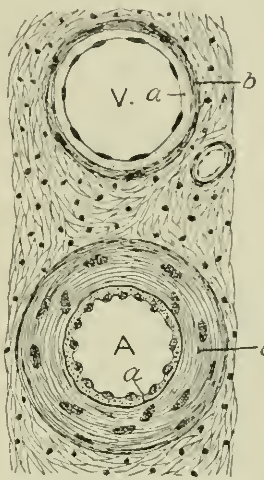
The rate of the heart's beating varies. In a baby



Section of left side of the heart showing the valves which prevent the blood from going out at the same opening where it came in.

it is about a hundred and thirty times a minute, in a child of eight or nine years old it is about ninety times a minute, and the rate gets slower until it is

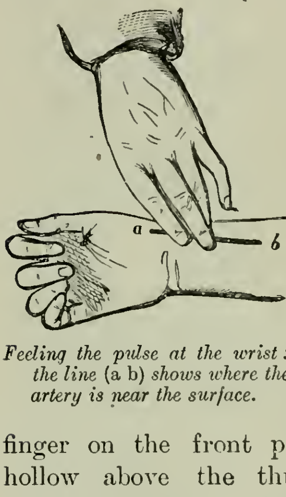
about seventy times a minute in a grown-up person. That is the rate when it is beating quietly. If we are doing hard work, or running or jumping, the heart beats much more quickly. When a person suffers from fever, there are some substances circulating in the blood which make the heart beat very quickly; certain drugs, too, have the same effect. The heart does not beat at quite the same rate in different individuals. Napoleon, for example, is said to have had a very slow heart, which beat only forty times a minute.



Section of small artery (A) *and vein* (V) *showing inner lining* (a) *and muscular fibres* (b).

When the heart muscle contracts, the blood is forced from the left side of the heart into a wide tube; the tubes or blood-vessels through which the blood flows from the heart are called *arteries*. There is a beautiful arrangement in the heart which prevents the blood from flowing in the wrong direction. At the various openings there are strong flaps or pouches forming valves or folding doors which open only in one direction. When the heart contracts, the valves shut and prevent the blood from going out at the opening where it came in. The doors of the arteries open outwards, and they allow the blood to pass freely, but close to prevent it flowing back again. The great artery divides into many branches, by which blood is carried to all parts of the body.

The structure of these tubes or arteries is very interesting. The inside consists of a smooth membrane; when this is examined under the microscope, it is seen to be made of cells arranged like a smooth pavement. This smooth lining extends through all the parts of the circulatory system. It allows the blood to flow easily and quickly along the tubes or vessels; indeed, it is found that a rough surface makes the blood form into clots, and stops its flow.

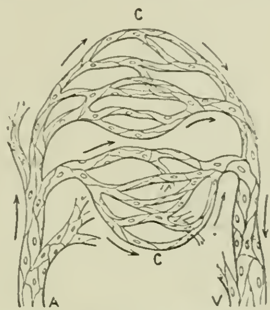


Feeling the pulse at the wrist: the line (a b) *shows where the artery is near the surface.*

Outside this smooth lining the walls of the arteries are formed of two sorts of fibres, elastic fibres and muscular fibres. In the larger arteries the elastic fibres are present in great numbers. This allows the walls of these arteries to distend when the contraction of the heart sends a sudden wave of blood into them. Place your right forefinger on the front part of your left wrist, in the hollow above the thumb, and you will feel the beating of your pulse. This pulse is the sudden expansion of the artery caused by the blood sent forward from the heart at each beat or contraction. If you count the beats of your pulse, you will find that their rate is exactly the same as that of the beats of your heart — probably about eighty in a minute. There is a pulse in all the arteries. Doctors usually feel the pulse at the wrist because a large artery passes near the surface at that point, and the throbbing can be easily felt. You may also be

able to find a pulse in the side of your neck or in front of your ear.

In the smaller arteries the muscular fibres are most numerous, and these fibres have a very interesting work to perform. You know that when you feel shy or ashamed you blush; your face and neck turn red. The small arteries of the face and neck are suddenly filled with more blood than before, and this is due to the muscular fibres of their walls relaxing, and the tube becoming wider for a time. When you have been working vigorously, and feel hot, the same thing occurs all over your body. The chief use of this arrangement is that more blood comes to the surface of the body, and thus it gets cooled down when it is too hot. If you are cold, or if you have been suddenly startled, the muscular walls of these small blood-vessels contract; the tubes become narrower, and less blood can flow through them. You then become pale, from the lessened quantity of blood in the skin.



A network of capillaries (C, C) *between an artery* (A) *and a vein* (V).

It is not only in the skin that the small arteries act in this way. Whenever any part of the body is being used, it receives by this means an increased flow of blood for the time. Thus the walls of the stomach are flushed with blood when digestion is going on; the muscles get an increased supply when they are doing work; and so with other parts of the body.

We have seen that as the arteries carry their current

of pure blood from the heart to all parts of the body, they divide up and become smaller and smaller. At last they subdivide into a network of very minute tubes, so small that they cannot be seen without a microscope. These vessels are called *capillaries*, or hair-like vessels, but they are really much finer than hairs. As the vessels get smaller, their walls get thinner, and in the smallest vessels the wall is simply the smooth lining membrane and nothing more. It is while the blood is passing through these capillaries that its work is done. The oxygen which it gathered up in the lungs, and the nourishing matters which it received from the food, now pass through the thin wall of the vessel and reach the tissues where they are needed. At the same time the waste material of the tissue is returned to the blood and carried away by its flow. A large quantity of water is given by the blood to the various soft tissues; these are indeed constantly bathed in the colourless fluid which we call lymph.

These changes in the blood are accompanied by a distinct change of colour: from bright red it changes to a dark purplish colour. The capillaries which carry this impure blood join together again and form larger vessels called *veins*, through which the blood flows back to the heart. When the web of a living frog's foot is held under the microscope, we can actually see the blood coursing through the capillaries, with the red and white cells floating in the fluid. In Harvey's time there were no microscopes, so the circulation through the capillaries could not be seen by him. This makes it all the more wonderful that he was able to discover the circulation of the blood.

From the capillaries the impure blood passes into

the veins, as we have said, and these carry it back to the heart. The veins are very much like arteries in appearance. The small vessels begin among the capillaries, and gradually unite to form larger veins. The walls of the veins are thinner than those of the arteries, and they have valves here and there along their course somewhat like the valves of the heart. These valves prevent the blood from flowing backwards through the veins.


Section of a vein showing valves; the lower valve is open, the upper closed.

If we press on one of the surface veins, we can see it stand out in a thick bluish line under the skin. We may see "knots" in this blue line; these are the valves which prevent the return of the blood, and take the pressure off the lower veins when the blood is made to flow uphill. The flow of the blood through the veins is much aided by the contraction of our muscles when we take exercise. This squeezes out the blood from the muscle, and the valves keep it moving on in the right direction.

Before reaching the heart all the veins join into two large tubes, one carrying the blood from the head and the upper part of the body, and the other carrying that from the lower part of the body, and these two also unite near the heart. The impure blood is thus poured into the right side of the heart, and is then pumped from the heart to the lungs to be purified. As it flows along the tiny capillary vessels in the lungs, the blood gives up the carbon dioxide and water which it received from the tissues, and takes in oxygen from the air. Then it flows back again through a series of veins which bring it to the left side of the heart, ready to start

off once more on its life-giving journey through the body.

Some experiments have been made in order to find out how long it takes the blood to make this double circuit which we have described, and it has been found that the time occupied in the complete journey is only about twenty seconds; in a young child the time is even less. It does seem wonderful to think of a tiny drop of blood rushing through the whole body three times in a minute.

We cannot control our circulation by our will. The heart goes on beating without our knowledge, and the flow of the blood needs no help from us. There are certain nerve-cells in the brain that regulate the movements of the circulation. Nerves pass from these cells to the heart: some of these tend to slow down the rate of its beating, and others have the power of quickening it. When people are well and their heart action goes on smoothly and regularly, these two sets of nerve fibres preserve a balance. Nerve fibres also go to the arteries; some of them have the power of causing the muscles in the wall of the artery to contract, while others make it dilate. The circulation requires very careful nerve control, and it is well that all this goes on without needing any attention from us.

There are several things which we can do, however, to help in this very important matter. The circulation is always best in people who take plenty of exercise. We have seen that when a muscle is being used it gets an increased supply of blood. This helps the movement of the blood. Again, when one of our muscles contracts, it squeezes out the blood and the lymph from the vessels within it, and the return flow of the blood is thus helped on.

You will see how much the circulation is helped by the work of the muscles if you think how much colder and more tired you feel when you are standing still than when you are moving about. Some people who are not strong feel quite ill if they have to stand for a long time. If they can move about and help their circulation by the exercise of their muscles, they feel better. Soldiers sometimes become faint from long-continued standing, and they are helped by being allowed to " mark time."

Another way in which we can help our circulation is by deep breathing. This assists the flow of blood through the lungs and helps in its return to the heart.

We can also help by keeping the muscles of the heart and of the arteries in good condition. This requires first of all that we should supply them with plenty of nourishment, but it also means that they should have sufficient work to do. Whenever we take exercise, we are giving the heart a little additional work to do, and thus helping to make it strong and vigorous. We can also brace up and exercise the muscles of the arteries by taking cold baths followed by vigorous rubbing. This provides exercise for these muscles by making the walls of the arteries contract and dilate.

We must not expect that our circulation will work well if we require it to do two things at once. After a full meal, when a large supply of blood is needed by the stomach in order to help on digestion, we must not call for a blood supply to the muscles at the same time, by taking active exercise, or to the brain, by sitting down to study. The brain requires a good supply of blood to carry on its work just as much as the muscles do, and neither of them can get this supply

just after a meal without reducing the flow of blood which the stomach requires.

In training our heart and blood-vessels to work well, there are some things we ought to avoid. We must not increase suddenly the amount of work we give them. The heart may be injured by too great exertion, especially if undertaken suddenly. Exercises should be increased gradually, in order to allow the heart to get accustomed to the increased demands upon it. Again, we must not continue any muscular exercise after we are out of breath. Breathlessness shows that both heart and lungs are being overtaxed.

CHAPTER XIV

INFECTION

Long ago families belonging to the same tribe used to live near each other for the sake of safety from enemies, as savage peoples still do in various parts of the world. In this way villages and towns arose. The enemies to be feared were the men of hostile tribes and the wild beasts which prowled around. We have no fear of such enemies in our country, but we still hear of encounters with wild beasts in other lands. Not many years ago, when a railway was being made in British East Africa, work was almost stopped by the attacks of lions upon the workmen. In India, even at the present day, over twenty thousand people are killed every year by wild beasts and poisonous snakes.

We have nothing to fear from such foes as these, but each of us is exposed to the attacks of enemies no less deadly. Although they are too small to be seen by the naked eye, they kill far more people every year than all the lions and snakes in the world. They are difficult to destroy just because they are so small. It will require a long and constant warfare if the world is ever to be rid of them, and in this warfare every boy and girl can help. Let us see what these enemies are, and how we can hope to conquer them.

You know that some diseases are *infectious*—that is to say, they spread from a sick person to others who may be near him or in contact with him. If one child takes measles, for example, other children in the same family or in the neighbourhood are likely to take the same disease. When a disease comes into a district in this way and attacks a number of people, it is called

The microbes which cause some common infectious diseases, as seen under the microscope—(1) *tuberculosis*; (2) *typhoid or enteric fever*; (3) *diphtheria*; (4) *malarial fever*; (5) *cholera*; *and* (6) *plague.*

an *epidemic*. For hundreds of years no one could find out how this happened, and so it was impossible to say how it could be prevented.

We now know that these infectious diseases are caused by very small living creatures which enter the body and remain there, increasing in numbers to an amazing degree. Some of them are so minute that they can only be seen by a microscope which magnifies one thousand times, and others are even smaller. They are called *micro-organisms*, or *microbes*, a name which

means very small living creatures; they are also commonly known as *germs*. Some microbes are called *bacilli*, on account of their shape; a *bacillus* is a germ shaped like a small rod or stick.

Some microbes belong to the vegetable kingdom, and others to the animal kingdom. Almost all of them are very simple in structure, consisting of only one cell. When they find themselves in suitable surroundings as regards food, moisture, and warmth, they multiply with extreme rapidity. They draw their nourishment from the substances around them, and cause great changes in these structures by their action, as we have seen in the formation of alcohol from sugar by the action of yeast germs.

All germs do not cause disease, however. Many of them are very useful to man. It is by the aid of microbes that plants are able to draw nourishment from the soil and thus to build up food for man. The "ripe" flavour of cheese is due to the action of small organisms, and the fermentation of wine and beer is caused in the same way. The process of rotting is also due to this cause; microbes attack and live upon waste material such as fallen leaves, and break up their substance into other and simpler substances which pass into the air and into the soil, ready to build up new plants. We do not wish to destroy such microbes as these, which are either harmless or do useful work for us.

It is the microbes which cause disease that we want to discover and to destroy, as far as we can do so. Microbes of disease enter the body in different ways. They may be swallowed with the food or with drinking water; they may be breathed in from the air, or they may gain entrance through a cut in the skin

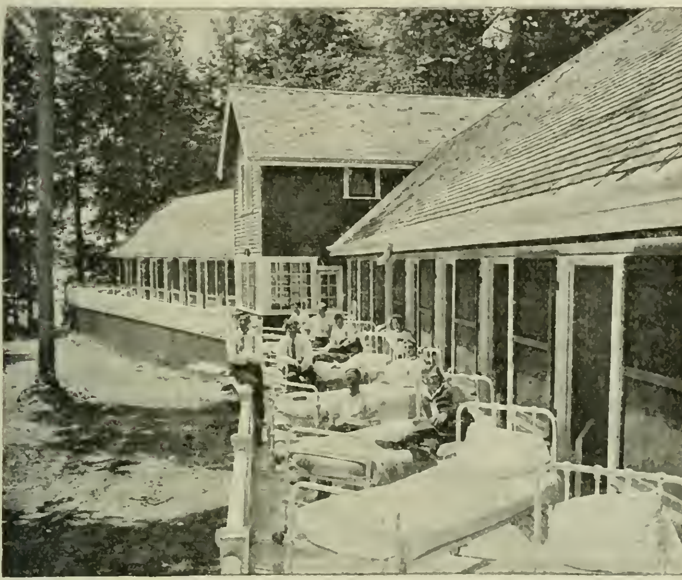
Different diseases are caused by different germs. One kind of germ causes scarlet fever, another diphtheria, another typhoid fever, and so on. When a person becomes ill with scarlet fever, it means that his body has been invaded by the germs which cause that disease, and the sore throat, the rash, and the feverishness which accompany his illness are signs of the fight which is going on between the germs and his body.

Now there are two ways of fighting an enemy. We can either find out where he is and what he is doing, and then attack and slay him on some suitable opportunity, or we can occupy some strong place and there defend ourselves against his attack. Microbes are to be fought in precisely the same ways. One way of fighting them is to keep the body so strong and healthy that they cannot make an attack upon it. This is a task which each person must attend to for himself. The other way of fighting the microbes is to find out where and how they live, and then destroy them in their haunts before they attack our body. For this work we need the help of doctors and others who study such matters, and we must be ready to do as they advise us.

One of the most destructive of disease germs, against which an active war is being waged at present, is known as the *tubercle bacillus*. It causes the dreaded disease of consumption, in which the lung is attacked and wastes away. In 1882 Dr. Koch, a celebrated German physician, discovered the microbe which causes this disease. It was found that the bacillus not only causes disease in the lung, but that the bones and joints, the covering of the brain, and many other parts of the body, are also attacked.

This disease is now generally called *tuberculosis*.

In the British Isles, one out of every ten deaths is due to some form of this disease, and much ill-health, loss of work, and poverty can be traced to the action of the small organism which is its cause. Ever since Koch's discovery, scientists all over the world have been



"The tubercle bacillus cannot thrive where there is much fresh air" (p. 164). *The patients sleep in the open air when possible.*

trying to find out more and more about this microbe—how it lives, how it is introduced into the human body, and what can be done to prevent this.

If we are ever to get rid of this disease, people must understand clearly that it is an *infectious* disease, and is easily carried from one person to another. When a person suffers from consumption, he usually has a cough, and the matter which he spits up from the

lungs contains millions of the microbes. This matter dries and becomes mixed with the dust; it is blown about by the air and is breathed in by other persons, and so the infection spreads. Everything which is coughed up from the lungs should be received into a paper pocket-handkerchief and burned. On no account should it be allowed to dry and mix with the air, either indoors or out of doors. The careful burning of all infected matter prevents the spread of the disease.

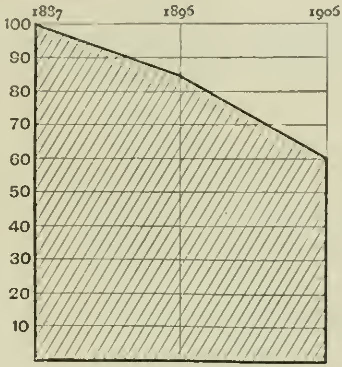
The tubercle bacillus cannot thrive where there is much fresh air and no dust. So in caring for those who are ill, and in keeping infection from those who are well, much good can be done by keeping the windows open so as to have plenty of fresh air in our rooms, and by living in the open air as much as possible.

People used to think that tuberculosis was hereditary; if parents suffered from the disease, their children were likely to inherit it from them. We now know that the children of such parents do not inherit the disease, but they are very likely to be infected with it by living in houses which swarm with tubercle bacilli. The very air of the rooms may be laden with them in the form of dust.

Cows and other animals often suffer from tuberculosis, and infection may pass from them to human beings. Milk is often found to contain tubercle bacilli. It is one of the duties of those who manage the affairs of our cities and towns to see that no infected milk or meat is offered for sale. Meat is usually inspected by skilled officers before it is sold. Attempts are also being made in most cities to secure a pure milk supply. The dairy cows are examined to see that they are

healthy, properly fed, and kept in clean, well-ventilated houses. Personal cleanliness is required in those who milk the cows, and the vessels into which the milk is received must be thoroughly clean. The milk should be kept in closed vessels until it reaches the house where it is to be used, and even then it is often wise to pasteurize the milk before using it, as most microbes are killed by pasteurization.

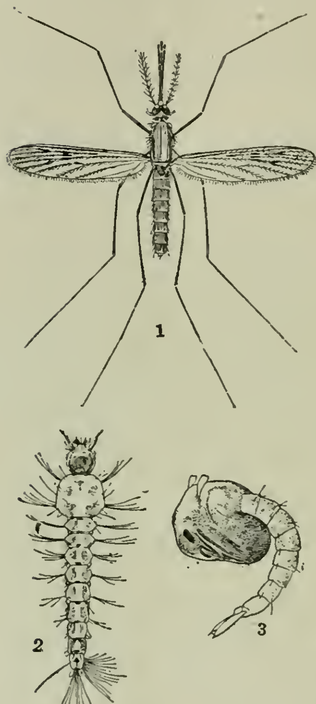
There is really no reason why tuberculosis should not be stamped out altogether. Fifty years after this, perhaps, when the disease has disappeared from the world, people will wonder why we allowed it to exist so long in our midst, just as we wonder to-day why our forefathers permitted the cruelty and suffering which were caused by child labour in mills and factories a century ago. The microbe can only carry on its ravages where there are dust, dampness, and bad air, and where people are poorly nourished. The provision of fresh air and sunshine, cleanliness, and good food is the best way of carrying on the warfare against it. Cleanliness is of the highest importance. Such filthy habits as spitting, or wetting the fingers with the tongue when turning over the leaves of a book or a roll of bills, do much harm in spreading the disease.



This diagram shows the decline in the death-rate from tuberculosis in Great Britain during twenty years.

Malaria is a feverish disease which sometimes attacks people who live in low-lying, marshy districts. This

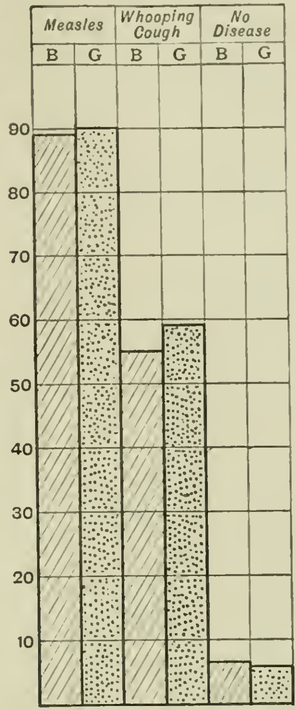
disease was formerly common in many places from which it has now disappeared, but in some parts of the world it is still a terrible scourge. It was long supposed that the disease was caused by damp air arising from the marshy ground. This is now known to be a mistake. Malaria is caused by a microbe being introduced into the blood through the bite of a mosquito. Why, then, should the disease be found only in marshy districts? Because mosquitoes are chiefly found in such places, and require stagnant pools of water to lay their eggs in. Wherever marshes have been drained, or where the young mosquitoes are killed by some oily substance being poured into all the stagnant pools, the mosquitoes disappear, and the disease also disappears. In this way certain parts of Central America and the West Indies have been freed from the plague of malaria.



The mosquito whose bite causes malaria, full grown (1), *and in the larva* (2) *and pupa* (3) *stages.*

There are many other infectious diseases which are known to be produced by microbes. Some are still very common, especially among young people, such as scarlet fever, measles, German measles, whooping-

cough, chicken-pox, mumps, and diphtheria. Most children have had one or more of these diseases. Some of them, such as chicken-pox, are usually very mild; others, such as diphtheria, are always serious. In some ways these diseases are very much alike. They are highly infectious, they last only a comparatively short time, and they rarely attack the same person twice. Almost all of them may cause serious injury to health. After all, there is no reason why we should suffer from any of these diseases, and we may hope for the time when they will disappear.



This diagram shows the percentage of school children (boys and girls) in a country town who had suffered from two common infectious diseases, and of those who had escaped all such diseases.

At present we try to stamp out such diseases by killing off the microbes in each case of disease. The person infected is kept away from others, either by being taken to a hospital or by being nursed in a separate room at home. Things which have been used by the patient should be at once burned, if they are of little value, and all furniture, clothing, and things of more permanent value, must be disinfected. To disinfect a thing is simply to treat it so as to kill any microbes which may find shelter in it. This can be done in various

ways. Great heat destroys microbes, and so clothing is disinfected by being put into a large oven or chamber through which hot steam is driven. There are certain chemical substances which also disinfect. The fumes of formalin or of sulphur may be used to disinfect rooms. Fluid disinfectants, such as carbolic acid, lysol, and Condy's Fluid, are also of service if properly diluted and used with sufficient care.

Thus far we have been speaking of diseases which are still common, although we are now trying to get rid of them. Some diseases are now much less frequently seen than they used to be. In civilized countries, plague, cholera, and smallpox are already rare, and even when they occur they do not infect a whole neighbourhood as they used to do. Yet in countries where little heed is given to public health and cleanliness, the ravages of these diseases are as terrible as ever they were. Hundreds of Chinese in Manchuria died of plague in the year 1910, and missionaries in Mukden and other cities said that the scenes which they saw reminded them of the stories they had read of the Great Plague of London in 1665. The Chinese magistrates were so ignorant of the nature of the disease and its prevention, that they tried to stop the plague by ordering the people to wear horses' bones tied to their arms. In India, too, plague is often very destructive, and the English magistrates and doctors have the greatest difficulty in persuading the people to use proper means of prevention against it.

Smallpox is now a somewhat rare disease, owing to the care which is taken to prevent infection when it does occur, and also to the practice of vaccination. Towards the end of the eighteenth century, an English doctor named Jenner noticed that dairymaids and other

workers among cattle were often infected by them with a mild disease called cow-pox, and that such persons either did not take smallpox, or took it in a very mild form. He therefore began the practice of *vaccination*—that is, of infecting people with the disease of cow-pox or *vaccinia* in order to prevent their taking smallpox, or to prevent its assuming a severe or dangerous form.

Many other diseases which used to afflict people have been gradually stamped out; and if everybody knew how infectious diseases can be prevented, with all the pain and suffering and loss which disease always brings, and if they would help to prevent them in the ways which doctors and other men of science point out, there is no doubt that we should soon get rid of many of the diseases which still exist among us.

CHAPTER XV

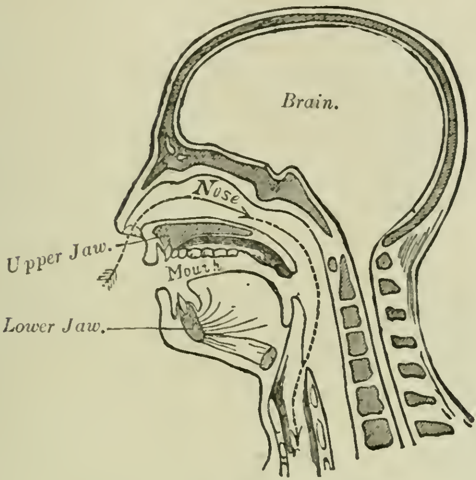
BREATHING

When a building is erected in which a large number of people are to be accommodated, the architect must provide some means of *ventilation*. He must see that plenty of fresh air is admitted for the people to breathe. In a large building fresh air is often pumped in through tubes, purified from dust, warmed, and moistened if necessary. The dust is removed by passing the air through a screen or filter of hemp or cocoanut fibre, and then through a trickling stream of water, which also renders it moist. If heat is needed, the air is passed over hot-water pipes.

It is only in recent years that architects have used such a method of preparing the air for breathing, but it is a very old device with nature, and we all have inside our nose an apparatus which produces the same result. The air which we breathe ought to enter through the nose. The mouth is intended for other purposes, and if it is used as an air channel, breathing is not carried on properly, and bad health is often the result. There is a good deal of wisdom in the old saying, "Shut your mouth and save your life."

The chambers behind the nostrils are not smooth, empty spaces. Several small bones project into them and form deep ridges on the walls. The membrane

which lines the walls of the chambers passes over these ridges as well, and so it has a much more extensive



How the air passes into the windpipe.

surface than if the walls were smooth, just as a pleated frill requires much more material than a plain band of the same length. There are good reasons for the lining membrane of the nose having a large surface. All over it there are small hairs growing, and these hairs catch particles of dust and other impurities, and prevent their entrance into the lungs.

Cells with very small hair-like projections on the surface.

The cells on the surface of the lining membrane have also some very small hair-like projections called *cilia*, which is a Latin word meaning "hair." The cilia are so small that they can only be seen with a microscope, but they have a very important work to do. They are

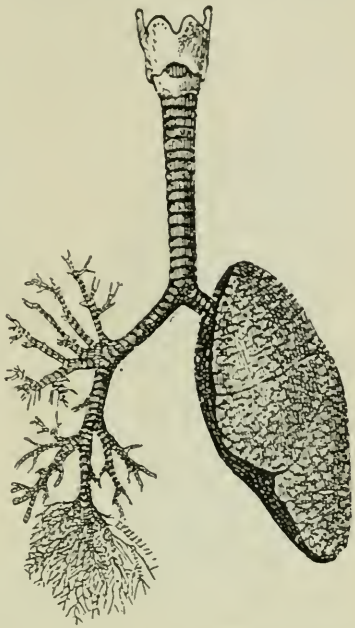
constantly in motion, waving to and fro, and they move in such a way that when any small particle such as a germ or a speck of dust settles upon them it is swept outwards to the nostrils and not allowed to pass down into the lungs.

The lining membrane of the nose contains a large number of blood-vessels, through which warm blood is always flowing. These act like the hot-water pipes in a building, and warm the air as it passes over them. The lining is also kept moist by means of special cells, and this moistens the air as it passes on to the lungs.

When the air has passed through the chamber at the back of the nose, it flows into the *larynx* or voice-box. The larynx can be easily seen from the outside as a prominence on the front of the throat. It is much larger in men than in women. The common name for this prominence is "Adam's apple," from the old legend that the forbidden fruit which Adam ate in the Garden of Eden stuck in that part of his throat. At the top of the larynx is a door, called the *epiglottis*. This opens and shuts like a trap door. It remains open while we are breathing, but when we swallow it shuts down while the food passes over it, so that no particle finds its way into the windpipe. If a crumb does go down "the wrong way," as we say, you know how it makes you cough until it is blown back from the windpipe.

The windpipe or *trachea* is a tube which carries the air down to the lungs. Its lining has ciliated cells like those of the membrane of the nose, and these also help to sweep out any impurity which finds its way into the windpipe. This tube must always be open to let the air pass, whether we are lying down or standing upright, and so its walls are formed of rings of cartilage, a substance somewhat like bone, but not so hard. Within

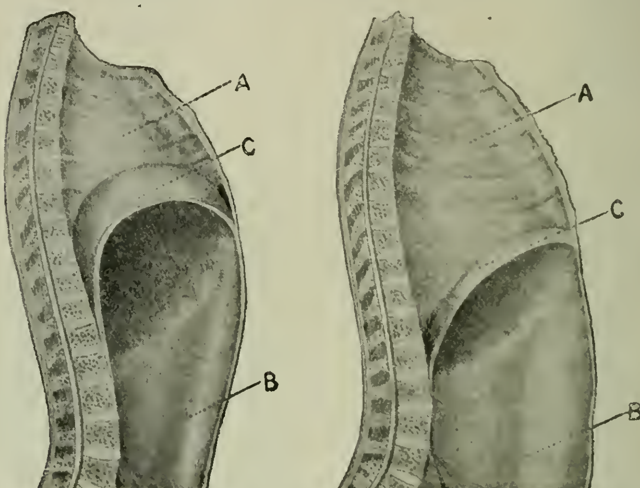
the chest the windpipe divides into two tubes, called the *bronchi* (each is called a *bronchus*), which pass to the right and the left lung respectively. The bronchi divide into smaller tubes, and these again and again into smaller and still smaller, until they end in little chambers or bags called air sacs lined with air cells.



The breathing organs. Note the larynx at the top, and the windpipe dividing into the two bronchi. On the left, the lung is removed to show the branching of the bronchus and in the lower part the smaller air-tubes.

In the walls of these sacs are vast numbers of tiny blood-vessels called *capillaries*, for all the blood in the body passes through the blood-vessels of the lungs every few seconds, as we have seen in another chapter. The walls of the air sacs and of the capillaries are very thin, and gases can pass through them. So in these sacs the air gives up to the blood some of the oxygen it contains, and the blood gives up the waste and poisonous gases which it has collected during its passage through the body. Now you can see the reason why we are always drawing in fresh air into the lungs, and then breathing it out again. We are really supplying fresh material to the blood, and carrying away waste matter from it.

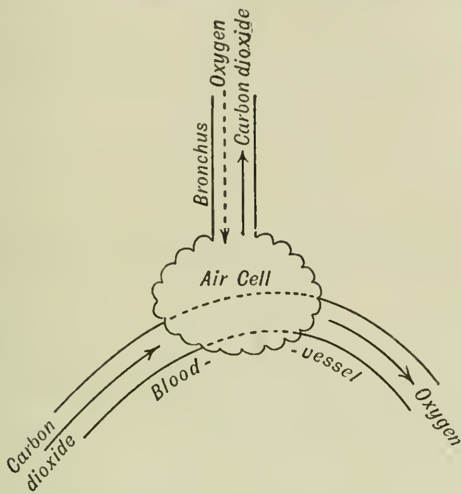
If you watch the breathing of your little brother or sister when asleep, you will notice that the chest rises and falls, and rises and falls again, quietly and regularly, about twenty times every minute. You can study the movements of breathing better by standing in front of a mirror when you have only light clothes on, as when



Section of the trunk showing the chest (A) *and the abdomen* (B) *separated by the diaphragm* (C). *Note how the lowering and flattening of the diaphragm in the figure to the right increases the size of the chest cavity, and pushes the abdomen downward and forward.*

you are about to go to bed at night. Then take some deep breaths slowly, and observe what happens. When you are breathing in, the chest rises and increases in size; at the same time the lower part of the body, or the abdomen, as it is called, is pushed forward. When you breathe out, the chest falls, and the front of the abdomen becomes flat again. The chest is moved by muscles which act on the ribs, pulling them up a little at the sides, and thus enlarging the cavity of the chest.

You have learned that between the chest and the abdomen there is a muscular membrane called the *diaphragm.* This is dome-shaped, being higher in the middle than at the sides. When we breathe in, the diaphragm becomes flatter, pushing the abdomen downward and forward, and leaving a greater space above



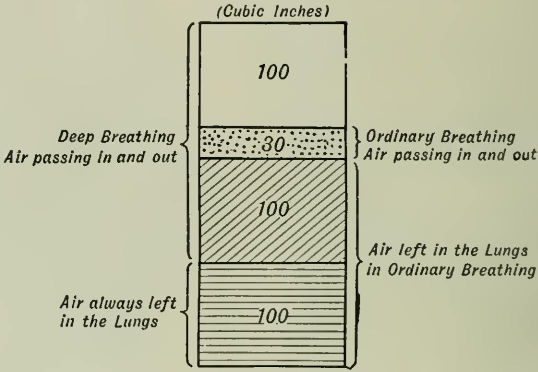
"*The blood and the air meet to exchange their goods*" (p. 176).

it in the chest. When we breathe out and the air passes out of the lungs, the chest falls back to its former position, while the diaphragm rises, allowing the abdomen to become flat once more.

The lungs act very much like elastic bags. When the air is allowed to escape, the bags slowly collapse. Have you ever seen the amusing toy which children call a "dying pig"? It is an india-rubber bag which is shaped like a pig when it is distended with air. As the air escapes, the pig makes a

squealing sound and slowly collapses as if it had fallen down dead. The lungs act very much in the same way, except that the air passes out noiselessly.

There is another important difference between the lungs and the "dying pig." The air which escapes from the rubber bag is the same as the air which was put into it. The air which escapes from the lungs, however, is very different from that which entered them. In the lungs, as we have said, the air gives up



This diagram shows the quantity of air breathed in and out in ordinary breathing and in deep breathing.

oxygen to the blood which flows through the capillaries in the walls of the air sacs, and in exchange it gets carbonic acid gas or carbon dioxide and water from the blood, which are waste materials that the body must get rid of. The air cells are a kind of market-place where the blood and the air meet to exchange their goods.

The great bulk of the outside air is a gas called nitrogen. This gas goes into the lungs and comes out again practically unchanged. Its chief use in breathing is to mix with the oxygen so as to dilute or weaken it.

Pure oxygen is too strong to breathe, and would soon cause death.

The lungs are never quite empty of air. By an ordinary breath, a man takes in from twenty to thirty cubic inches—that is, about a pint—of fresh air to mix with that in the lungs. By breathing very deeply, about one hundred cubic inches more can be taken in, and one hundred cubic inches of the air usually left in the lungs can be breathed out. You can easily see, therefore, that a few minutes' practice of deep breathing gives an enormously increased supply of oxygen to the blood. Deep breathing, as we have seen, is not done by means of the chest alone; it is chiefly the work of the diaphragm. When we stand up to practise deep breathing, we must see that the abdomen is forced well downwards at each breath.

We have said that water is carried away from the blood by the air which we breathe out. This water comes out in the form of vapour. Stand close to a cold looking-glass and take a few deep breaths. The moisture in your breath forms tiny beads of dew or water upon the cold glass and makes it quite dim, so that you can no longer see your face in it. On a cold day the moisture of your breath is seen in the form of little clouds of steam coming from your nostrils or your mouth when you are running about.

You cannot see the carbon dioxide and the other impurities which the breath contains, but there are other ways of knowing that they are present. Have you ever entered a room in which a number of people have been sitting for some time with the door and windows closed? If so, you must have noticed an unpleasant odour in the air, and perhaps after being in the room for some time you had a feeling of tiredness,

or a slight headache. The unpleasant odour of a crowded room is probably due to impurities from the skin and the clothing, and it is always most disagreeable among people who are not careful about personal cleanliness. The "stuffiness" of the air, which causes headache, is the effect of the carbon dioxide which has been breathed into it.

A person breathes continuously all through life from the time of his birth until death comes. Breathing goes on independently of our will. We breathe without having to learn how to do it, and we go on breathing without paying any attention to it. What is it that maintains the regular rise and fall of the chest and the regular expansion and contraction of our lungs day and night all our life long? There is a small group of nerve cells in the brain which controls these movements. These cells work ceaselessly, and if they stop life itself stops.

Though you do not manage your breathing for yourself, and though these nerve cells carry on the work without your attention, you can affect the process in some ways. You can change the rate and the degree of movement for a time. You can practise taking deep, full breaths, as we have said. This is an excellent thing to do, for a well-expanded chest and well-filled lungs give the blood a chance of being well purified. Good pure blood gives all the tissues of the body good nourishment. You can also hold your breath or cease breathing for a time. You can hold your hand tightly over your nose and mouth so that no air enters. If you do this and count slowly in your mind, "one—two—three—" and so on, you will find that by the time you come to "twenty-five—twenty-six—twenty-seven—" your head begins to feel stupid, and almost before you know it you

have removed your hand. What is the reason of this? When you hold your breath, the lungs cannot send out their waste products and receive fresh air. The blood flowing through your body remains impure. This impure blood irritates the brain cells concerned in breathing, and they send such emphatic messages to the lungs and breathing muscles for fresh air that you can no longer keep these from acting. The demand of the brain cells for fresh air is stronger than your determination to hold your breath, and the lungs act in spite of you.

There are other things beside changes in the blood which irritate or stimulate those brain cells. You gasp or take a quick, deep breath when cold water is suddenly dashed on your skin. You hold your breath when you feel a sharp pain, and when you listen intently or attend keenly. Exercise stimulates the action of the lungs.

It is very important that the delicate tissues of the lungs should be protected from injury. You already know one way in which they are protected. The small hairs in the nose and the cilia of the lining of the nose and the windpipe prevent the entrance of dust, germs, and other irritating particles. There are other means of protection which we may now consider.

In the nose there are special nerve structures which give us the sense of smell. This special sense is described in a later chapter, and at present we need only consider its use as regards the protection of the lungs. By the sense of smell we are warned of the presence of many poisonous gases in the air. Ordinary coal gas, which is used for lighting and heating, is one of those poisonous gases which have a disagreeable odour. Unfortunately there are some highly poisonous gases which have no smell, and are, therefore, all the more dangerous. Carbon dioxide, or carbonic acid gas, has no smell, as we have

already explained. Carbon monoxide is a gas often found in old wells and in coal mines, and is sometimes produced by stoves. It has no smell, and is a very dangerous gas, generally causing the death of any one who breathes it in.

There is another way in which the lungs are protected. Sometimes an irritating particle, such as a crumb of bread, gets into the windpipe. The lungs protect themselves from such an intruder by the act of coughing. When you cough, air is blown out suddenly and forcibly through the mouth in order to expel the irritating substance. When you sneeze, air is forcibly expelled in order to get rid of something which is causing irritation in the nose.

In former days the taking of snuff was a common habit. It was an act of courtesy to offer snuff to a friend, and for this purpose a man of fashion always carried a finely-decorated snuff-box. Snuff consists of small particles of dried tobacco leaf, and when introduced into the nose it irritates the lining membrane and causes a sneeze. Fortunately, this uncleanly habit is no longer considered a part of good manners.

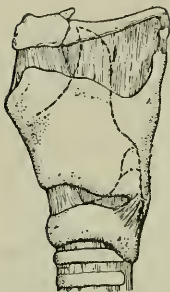
Coughing and sneezing are caused not merely by impurities which enter the air passage from without; they also serve to free the nose, the windpipe, and the lungs from the obstructions caused by diseased or unhealthy conditions. A cough is almost always present when there is disease of any part of the organs concerned in breathing. We should regard it as a danger-signal. People often give little heed to this warning, and say, "Oh, it is only a cough!" Whenever a child, or even a grown-up person, has a cough there is something wrong. It may be very little, but it should be attended to, and, if possible, put right.

CHAPTER XVI

SPEECH

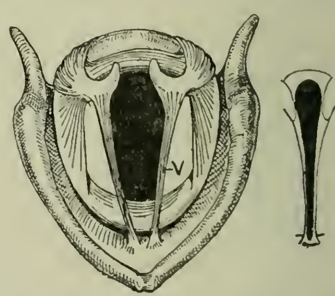
One of the ways in which man differs from the lower animals is in having the power of *speech*. He alone can express his thoughts by means of articulate sounds which we call *words*. Most animals can produce sounds, and these sounds are usually of a very distinct and definite kind—lions roar, dogs bark, cats mew, birds chirp or sing, and so on. By means of such sounds, too, animals do communicate with one another. Birds can give a cry which indicates the presence of danger, and so warns other birds. A writer who has studied that very intelligent bird, the crow, tells us that he can recognize quite a number of different calls which it gives, each having a distinct meaning or purpose. A person who keeps fowls will soon learn to understand the different calls which a hen uses for her chickens. The higher species of monkeys are said to have quite a language of their own. One student of animal life claims to have been able to distinguish at least twelve different sounds or words uttered by chimpanzees, and he thinks they probably use more than these. But even this falls far short of what we mean by language, and corresponds rather to the different cries which a baby might utter before his mind has reached the stage of thinking.

The vocal sounds which make up speech are produced in the *larynx* or voice-box. This is the name given to the wide upper part of the windpipe, forming the raised protuberance on the throat which, as we have said, is sometimes called "Adam's apple." The walls of this box or chamber are made of cartilage, a substance somewhat like bone but not so hard or unyielding.



The outside of the larynx or voice-box, side view.

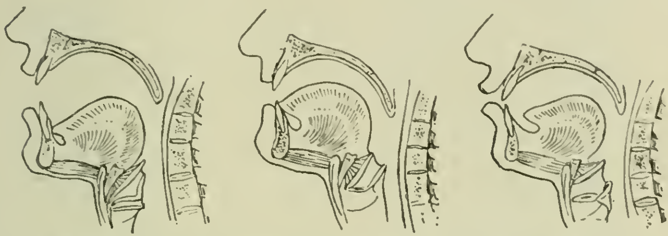
A Spanish singer thought it would be a good thing if we could see into the larynx and learn how sounds are produced by it, and he invented a method of doing this. A small mirror is held in the back of the mouth above the opening of the windpipe. A beam of light is thrown upon this from another mirror, and is reflected down upon the larynx. The reflection of the larynx itself can then be seen in the mirror at the back of the mouth. This method of examining the larynx is now regularly used by doctors.



The larnyx and the vocal cords (V) *seen from above the opening as in quiet breathing. On the right is shown the opening when a high note is being sung.*

When the larynx is looked at in this way, we see two folds of fibrous tissue covered with a delicate membrane stretching across the top of the chamber, one at either side, leaving a small opening between them for the passage of air. The edges of these folds are

known as the *vocal cords*, because it is the vibration of these edges that produces vocal sounds. All sounds are due to vibrations in the air. In all musical instruments there are parts which vibrate and cause sound-waves or vibrations in the air. Thus in the piano, the wires are struck by a small hammer and made to vibrate; in a violin, the strings vibrate when the bow is drawn across them; in an organ, the loud swelling notes are produced by the vibration of the columns of air in the organ pipes.



These drawings show, in section, the shape of the mouth cavity when we pronounce "ah," "ee," and "oo" respectively.

In the larynx, the vocal cords are drawn close together when we speak or sing, and the air is forced out between them, causing the edges to tremble or vibrate rapidly. This is one of the most wonderful things in the human body. The air comes from the lungs merely as waste, and yet it is used to produce the sounds of the human voice, with all its variety of musical tones, and its still more wonderful variety of articulate words by which man expresses what he feels, what he thinks, and what he hopes for.

There are other structures besides the vocal cords which are concerned in producing speech. By means of muscles in the larynx, the position and the tension of the cords can be altered so as to produce high or low

sounds. We can change the shape and size of the cavity above the larynx, the air passages, and the mouth, and we can alter the position of the tongue and the lips so as to form the different sounds of our words. When you pronounce "ah" and then "oo" before a mirror, you can see that the form of the mouth changes for the different vowel sounds. The consonant sounds are produced by changes of a similar kind. Pronounce "be," and you see that your lips are first closed and then suddenly opened. So much do we use our lips in speaking, that deaf people can be trained to know what is said by watching the lips of the speaker. This is called "lip-reading."

Very young children cannot speak. This is partly because they have not begun to think much; they have not many ideas to express, and they cannot understand the meaning of our words when we speak to them. But it is also partly due to their not having learned to use the muscles which shape the sounds of the larynx into words. They must learn the use of these muscles gradually and by practice, just as they must learn the use of the muscles by means of which we stand or walk or run.

You all know how babies begin to speak by using simple sounds at first, such as "ta-ta, ma-ma," and how they gradually come to know and to use more words day by day. They learn to say the words which they hear used by others, and so young English children learn English, and French children French. Not only do they learn the language which they hear, but they learn to speak it in the same tones and with the same accent as the older people among whom they live. Each country and district has its own way of pronouncing certain sounds, and you can often tell where a person comes from by his pronunciation or

accent. The curious thing is that most people speak all their lives with the accent which they learned when they were young children, or if they do change, there is some slight trace of that accent left. Thus you will find

" *A great singer* " (p. 186). *Jenny Lind, or Madame Goldschmidt, the most famous singer of the nineteenth century.*

people who have lived many years in Canada, and yet you can tell as soon as you hear them speak that they spent their childhood in Scotland or in England. Children should take the trouble to speak properly when they are young, for the habits of

speech which they form then will be very hard to change afterwards.

The movements required in singing are often very difficult, and years of diligent study and training are needed to make a good singer. More than this is needed—the "natural gift," as some people call it, without which no one can be a great singer. But whether we have the gift of song or not, we can all learn to speak in a becoming way—not only to use the proper words, but to pronounce them as they ought to be pronounced, and to cultivate a pleasant and agreeable tone of voice. It is all a matter of attention and practice, just as the training of the muscles is in dancing or swimming or playing ball.

Lord Rosebery said recently, when addressing a number of schoolboys, that there are two things about which boys are apt to be careless: they slouch when they walk, and they pronounce their words in a slovenly way. Both habits are certainly too common, and both are very undesirable. Training the muscles in each case to a more precise and correct action is the way to cure these habits. And this would not only improve the manner of walking and of speaking; it would give the boys more control over their muscles generally, and make them more efficient and strong-willed men in after life.

CHAPTER XVII

FRESH AIR

You have probably read the story of the Black Hole of Calcutta. In 1756 an English fort at Calcutta was captured by the native prince of Bengal, Surajah Dowlah, who caused the English prisoners, one hundred and forty-six in number, to be shut up in a small dungeon. This dungeon was only eighteen feet in length and the same in breadth. There the unfortunate men were compelled to spend a long summer night in the hottest season of the year. Only two small openings placed high in the wall gave entrance to air, and these were partly blocked up by the buildings near. The prisoners suffered agonies from the lack of fresh air, and when the door was opened in the morning only twenty-three out of the hundred and forty-six men were found to be alive.

Such a tragedy, one might think, could not fail to be remembered as a warning. Yet we find that a hundred years later a very similar disaster occurred, which is, however, not so well known. A ship called the *Londonderry* set sail from Sligo, on the west coast of Ireland, bound for the port of Liverpool in England. The weather became very stormy. The captain sent the two hundred steerage passengers down below for safety, and ordered the hatches to be closed. The poor people were packed together in

a space not much larger than the Black Hole of Calcutta. Their sufferings were dreadful. When the hatches could once more be opened, it was found that no less than seventy-two of them had died.

Why were the English soldiers at Calcutta unable to live for one night in their dungeon? Why had those steerage passengers, who were confined below to save them from the sea, been unable to survive until they were set at liberty again? They died because they were not supplied with fresh air. The air which reached them was insufficient in quantity and was also impure.

In considering the necessity of a supply of fresh air to support our life and to keep us in health, there are three things important for us to understand. These are, first, why we need fresh air; second, what fresh air means; and, third, how much fresh air we require.

All animals need fresh air. If a mouse is put under a glass bell-jar, it moves about quite briskly, examining its prison and looking for a way out. If a little oxygen gas is now pumped into the bell-jar, the movements of the mouse become much more lively. If no oxygen or no fresh air is allowed to enter the jar, the breathing of the animal gradually uses up the oxygen which is already there. At the same time the carbon dioxide breathed out from its lungs mixes with the air in the jar. The effect of this is that the mouse becomes less and less active and energetic, and slower in its movements. If we did not take pity upon the little creature and either set it free or admit fresh air into its prison, it would certainly die, just as the soldiers did in the Black Hole of Calcutta.

"*The pure air of the mountains all around*" (p. 196).—[*June in the Austrian Tyrol,*
by John M'Whirter, R.A.]

We have already learned that we must be supplied with oxygen in order to maintain our life, and it is also necessary that waste gases should be removed from the body. The air in which we live does both these things for us. It brings to us the oxygen which we need, and it removes the waste carbon dioxide. The air as we find it on the surface of the earth contains just the proportion of oxygen which we require. If you think of it, you will see that we really live and move about at the bottom of a sea of air, just as certain sea-animals on the ocean bed live at the bottom of the sea of water. When we climb a lofty mountain peak, we may have some difficulty in breathing; the air is "rarer" or less dense, and each breath that we take draws a smaller supply into our lungs than when we were at the foot of the mountain. If we descend a deep well or a mine we may find that the air is full of poisonous gases. On the usual surface level, however, the human body finds just the air it needs.

There is one difficulty which may occur to you here. Since men and animals have been breathing in oxygen and breathing out carbon dioxide into the air for thousands of years, how does it happen that the air is still pure? It might seem as if the accumulation of carbon dioxide would have made it useless or poisonous long ago. The continued purity of the air is really due to the action of plants. Through tiny openings in their leaves, especially when the sun is shining upon them, they draw in the carbon dioxide from the air. This gas is composed of carbon and oxygen; the plant builds up the carbon into its own substance, and gives back the pure oxygen to the air.

The air is also kept pure by its currents or winds. Air is always being moved from place to place and mixed up together. Besides this, all gases have a tendency to spread and mingle when they come in contact with one another. In this way the air is kept equal in its composition and quality all over the world.

When air is shut into a room and prevented from mixing freely with the outside air, it seems to lose its freshness and become musty and unpleasant. If, besides this, there are people in the room and the waste gases from their breath are being mixed with the air, while the oxygen is being used up, as in a badly ventilated bedroom, the air becomes most disagreeable and unwholesome. We speak of the air in such a room as "close." Even out of doors, in the narrow streets and squares of a great city, the air feels close when there is a want of free movement and circulation.

Fresh air is air which contains a sufficient quantity of oxygen and which is free from impurities. What are those impurities which render air unfit for breathing? The most common is carbon dioxide, which comes from the breath of man and other animals. Carbon dioxide also comes from other sources. It is produced in all processes of burning or combustion: for burning simply means the uniting of oxygen and carbon into carbon dioxide at a rapid rate, so as to produce heat and sometimes light as well. The burning of coal or wood in furnaces and stoves, and the burning of gas or oil or wax for lighting purposes, all add to the impurity of the air by producing carbon dioxide.

We can see how the burning of a candle affects the air if we take a glass jar and invert it over a

Out-of-doors in the City: a Public Park in Germany.—[*By A. Plinke. By permission of Mr. Franz Hanfstaengl.*]

lighted candle, taking care to prevent the entrance of fresh air by letting the mouth of the jar rest in a shallow dish containing some water. The candle burns quite well for a time. Then its light becomes dim, and it flickers and finally goes out. The explanation of this is that the candle has gone on burning as long as the supply of oxygen lasted. When this was all converted into carbon dioxide, the process of burning could no longer continue. An ordinary gas jet produces as much carbon dioxide in a room as the breath of three people. A coal-oil lamp causes as much impurity as seven people or more, according to the size of the flame. Electric light adds no impurity to the air, and for this reason is a much more suitable light for our houses.

In addition to the carbon dioxide produced by breathing and by burning, there are other impurities added to the air in the form of fumes and smoke from fires. Sometimes a highly poisonous gas is given off by a badly burning stove. Tobacco smoke also makes air impure. Gases are given off by decaying rubbish. Dust of many kinds is mixed with the air. It usually consists of small dry particles from the soil and from the unburnt carbon of smoke, and fine "fluff" of cotton and wool from the wear of clothing and other fabrics. These are all irritating or injurious to some extent if they enter the body, but the chief danger of dust is that it often contains small living organisms such as moulds and the germs of disease.

We can sometimes judge of the impurity of air by smell, but not always. Carbon dioxide, as you have already learned, has no smell; but the impurities which are usually found along with it—impurities from the skin and from clothing, for example—give the

air a distinctly unpleasant odour, and this is useful as a warning. It is a pity, as one writer suggests, that impure air is not coloured dark blue. Then we could see it and avoid it.

Although we are aware that the want of oxygen, or the presence of much carbon dioxide, will cause death, we may think that a little impurity in the air we breathe does not matter much. This is a mistake. Although it does not kill people outright, it weakens the health and opens the way to disease. The death-rate in a city is always greatest where the people are crowded together in small houses and close rooms. Disease, especially tuberculosis, is always most common in such places. Indeed it has been said that the tubercle bacillus is the only thing that flourishes in bad air. And where that flourishes, man dies.

Some years ago, when doctors began to realize how tuberculosis is spread by means of dust and bad air, people who were suffering from that disease were often sent to the mountains of Switzerland. Their health improved in the fine pure air. Yet numbers of the Swiss peasants who lived among these mountains died of the very disease that other people went there to recover from. How was it that the visitors improved in health in the neighbourhood where the peasants died from the same disease? It was because the peasants lived in close, ill-ventilated houses. They had the fine pure air of the mountains all around, but the air inside their houses was often very impure indeed.

The health of animals as well as men requires abundance of fresh air. Some years ago the cavalry horses of the French army were found to die in great

numbers. As the strength of an army depends upon a plentiful supply of horses, this high death-rate caused much alarm. Some one suggested that the ventilation or air supply of the cavalry stables should be improved. This was done, with the wonderful result that the

Out-of-doors—a class in the "Forest School," Toronto.

death-rate among the horses was reduced to one-seventh of what it had been. Cow-houses also require free ventilation, and the condition of the cows is often improved by the provision of a better supply of fresh air.

Even when it does not cause disease or death, bad

air interferes with the general feeling of well-being which good health ought to give. People who live in close, stuffy rooms suffer from headache and loss of appetite. They do not sleep soundly. They do not wake up fresh and fully rested. They are not alert and vigorous. Their work is apt to be badly done. When a schoolroom is close and badly ventilated, the children get tired and listless and cannot keep up an interest in their lessons.

When we realize the effects of breathing bad air, we see how necessary it is to secure an abundance of fresh pure air. The best way to get this is to spend as much time as possible out-of-doors, whenever the weather will permit. If we attended even to this one thing, the benefit to health would be great. But we cannot always be out-of-doors. Our work as well as the weather may confine us indoors. We must then see that fresh air is freely admitted to our houses. The best way of admitting fresh air is to have the windows open constantly, day and night. Sometimes the cold of winter prevents this being done; but if we realize the benefit of fresh air, we may find it possible to open our windows much more freely than we have been in the habit of doing.

In severely cold weather, air is often admitted by the basement of the house and passed over radiators or furnace pipes to warm it before it enters the living rooms; while an escape is provided for the impure air. Under such an arrangement as this, however, the air never feels so fresh as when it enters directly from outside.

All systems of ventilation depend on the fact that heated air expands and becomes lighter, and that as it rises colder air flows in to take its place. When rooms

are warmed by open fireplaces, as in England, ventilation is comparatively easy. The fire sends a constant current of air up the chimney, which thus becomes a ventilating shaft for the room. Open fires are extremely wasteful of coal, and cause much dust, but they certainly promote freshness of air in the rooms.

Out of doors—a sewing lesson in the "Forest School," Toronto.

We have not yet mentioned how much fresh air should be admitted into a room for each person in it. It has been calculated that a man requires 3,000 cubic feet of air every hour, and a child about 2,000 cubic feet. You may not find it easy to realize just how much 3,000 cubic feet is. If you have a tape measure, you may measure one of your rooms at home,

and then multiply together its length, breadth, and height; this will give you the number of cubic feet in that room. For example, a small room which measures 10 feet long, 10 feet wide, and 10 feet high, contains just 1,000 cubic feet of air, which is enough for one person for twenty minutes without ventilation. A somewhat large room, 20 feet long, 15 feet wide, and 10 feet high, contains 3,000 cubic feet. According to the rule which we have given above, if two persons are sleeping in such a room, the whole of the air in it ought to be changed every half-hour. This shows us how necessary it is to have a constant supply of fresh air.

The great difficulty in ventilation is to get a sufficient supply of air into a room without causing draughts. A draught is very unpleasant to many people, and to some it gives rise to a feeling of chill. But we can accustom ourselves to draughts so that we do not mind them. The benefits of fresh air are so great that they are worth having even at the cost of some small sacrifice at first. At the same time, a good system of ventilation ought to supply the fresh air required without causing draughts which would lead to discomfort.

Pure air is more important in bedrooms than in living-rooms. We spend a great part of our lives in bed. Bedroom windows should be kept open whenever possible, even if we should require an extra blanket for warmth. It is an extremely harmful plan to keep our bedrooms warm and cosy by shutting out the pure air. Some people still have the old idea that "night air" is harmful. This is an entirely false opinion. As Florence Nightingale once said, "Night air is the only air there is at night." The more

night air we allow to blow round our beds, the better will our health become.

Along with pure air we may mention sunlight as being one of the most important things to keep us bright and well. Sunshine not only helps to make us feel cheerful; it actually kills out the germs of disease. Careful housekeepers may complain of the sunlight causing the colours of their carpets and curtains to fade, but we must choose in such a case between faded carpets and the pale and faded faces of those who live in the house. We cannot all afford to have what we would like in the way of food or of clothing, but pure air and sunshine are provided free for all who will use them.

CHAPTER XVIII

THE NERVOUS SYSTEM—I

If some Rip Van Winkle who had slept for two or three centuries were to wake up to-day, and find himself in one of our modern cities, he would no doubt be surprised at the changes he would see, and the difference in our ways of living from those with which he was familiar. The school in which we may be reading this page would be a surprise in itself. The houses in which we live, with their water supply and drainage, and their gas or electric light, would be full of wonders; in his youth not even a king's palace possessed such conveniences. We can imagine his astonishment at the speed with which we travel in steamships, trains, and motor cars, and at the still greater speed with which we can communicate with people at a distance, and even at the other side of the world.

His idea of sending a quick message would be to entrust it to runners on foot, or to men travelling by canoe. If he had lived in one of the countries of the Old World, he would think of sending it by a stage coach, going at full speed along the highway, with fresh horses waiting at certain places along the road. We should find it very difficult, no doubt, to make him understand how we send tele-

grams along the wires which stretch for thousands of miles across the continents and under the oceans. Perhaps we might have to use an illustration which is said to have been given to a backwoods farmer when telegraph wires were first put up: "Imagine," we should say, "that your dog has a body long enough to stretch right across Canada. Then if we pinch his tail in Halifax he will bark in Vancouver."

Our Rip Van Winkle would be much surprised, no doubt, at so wonderful an invention as the telegraph. Yet our illustration might suggest to him that nature had been before us here. In the body of every dog, and not merely of the extremely elongated one which we have imagined, there is a natural telegraph which provides for rapid communication between the head and the tail. And the same kind of apparatus is provided in every human body, even in that of Rip Van Winkle himself—for this is not a new invention, although we have only recently begun to understand its wonders. This apparatus is called the *nervous system*, a name which includes the brain and all the network of nerve fibres which spread throughout the body.

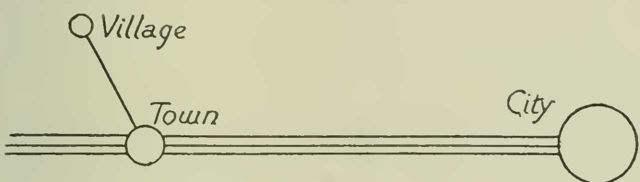
If you live in a small village near one of our western towns, and wish to send a message to a friend in Toronto, the first thing you will do is to go to the nearest telegraph office, write out your message, and hand it to the telegraph clerk. He will read your message, and then by pressing a key on the telegraphic apparatus at his desk he will send an electric current along the wire which leads to the nearest town. This will warn a clerk in the telegraph office there to prepare to receive your message. The words of the message are then trans-

"At full speed along the highway" (p. 200). *The stage coaches of last century.*

mitted as a series of long and short currents along the wire, each group of these standing for a certain letter of the alphabet.

The clerk in this town office now sends a similar series of signals to the central office in Toronto, and a clerk in that office writes or types out your message, letter by letter and word by word. Finally this written message is sent to the address of your friend in that city.

The various stages necessary for transmitting such a message are—(1) the receiving station at your local



How a telegram from the village reaches the city.

telegraph office; (2) the wire leading to the larger town; (3) the office in that town where the message is received and passed on; (4) the wire to the central office in Toronto; and (5) the central office itself, where your message is finally received and dealt with.

There may, of course, be only one section of wire between you and the city where your friend lives, or there may be several, and at each intermediate station the message may have to be taken down by a clerk and sent on to the next station. But in many cases the process must be somewhat like that which we have described. We cannot, of course, have separate wires from each village to every other village and town and city in the land. But each village is connected with some large centre near it,

and between the largest centres there are main or trunk lines consisting of a large number of wires. Sometimes these wires are formed into a cable such as the submarine cables that pass from the Old World to the New; sometimes they are laid in underground channels to prevent accidents from snow and storm. When the wires are placed close together, they must be covered with a sheath of some insulating material which will prevent the electric current passing across from one wire to another.

If we could peep into the room at some great central office where all the messages which pass over the wires are kept, what a strange mixture we should find them to be! There would be news of good and of evil, of joy and of sorrow; messages settling some great business affair, and messages telling of market prices, and gains and losses; reports of some great event which all the world is waiting for, and reports of local races and baseball matches. Our telegraph system not only links up all the scattered corners of the land; it touches all sides of our life, and we rely on its help in all kinds of affairs. When any district has its telegraphic connection with the rest of the world broken off, business almost ceases for the time.

Just as we need our telegraph system to keep the social and business affairs of our country moving on in a regular course, so in our body there is needed some central controlling power to keep all the parts of the body working in harmony. The lungs, the heart, the stomach, and all the other organs of the body are dependent upon one another, and each can do its own work only when the others are also doing their work. If there were not some means of communication to link every part together, the body

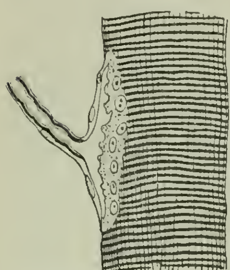
could not live. The means of communication is provided by the nervous system. The nerves form the telegraph system of the body, and in their action there are many points of resemblance to our electric telegraph system.

The telegraph system has its receiving stations or

"*At some great central office*" (p. 204). *The cable room of the General Post Office, London, England.*

offices where messages are handed in for transmission, and so has the body; its receiving stations are the ends of the nerves. These receiving stations differ greatly in appearance; those in the skin, for example, are not like those in the muscles. They also differ in certain stations being suited to receive messages of one special kind only, such as those of the eye and the ear. But they are all alike in their real nature, for each one is the end of a nerve.

Various sorts of messages are received and sent on from those receiving stations or nerve endings. Pain is the message which is sent from the nerve endings in a diseased or injured part of the body. Toothache is the message sent from the nerves in a decayed tooth, and it tells very plainly that the tooth requires attention. Wherever a pain may be, or of whatever kind, whether a sharp or a dull or a throbbing pain, this feeling of pain is a message which has been sent to the central stations of the body by a nerve wire which has its end in the ailing part.

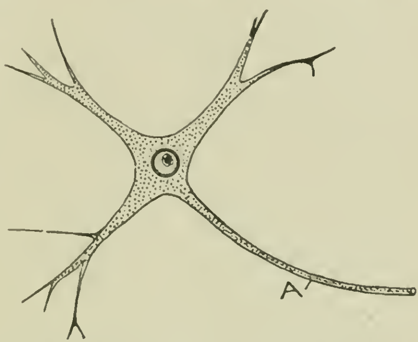


Nerve ending in a muscle fibre.

When the body requires food, we feel hungry. The feeling of hunger is a message sent from the nerve endings of the digestive tract along the nerves or wires which run to the central stations, and this message indicates that food is required. When we see the sun, our seeing is due to rays of light from the sun falling upon the nerve endings of the eye, which are specially designed to receive messages of this kind, and to send them along the nerves of sight. When we hear, the special nerve endings in the ear receive the sensations we call sound, and send these along the nerves to the central station.

We have said that the nerve endings correspond to the receiving offices of the telegraph system, and that the nerves act as the electric wires. There are also what we may call central telegraph stations in the body. These are collections of nerve cells, which we might compare to electric batteries, since they are

the sources of the energy by which messages are sent along the wires. Those collections of nerve cells are found chiefly in the brain; they are also found in the spinal cord, the thick mass of nerve tissue which passes from the brain down along the spinal column or backbone. From those central stations impulses are sent out in reply to messages received; for example, in reply to a message of pain in a certain part, the central station may send an impulse to the muscles of that part, causing them to move in a certain way, and so get rid of the pain.



A branching nerve cell. Note the nerve fibre A.

If you lay your hand on something which is very hot, you pull it back at once. You do the same if the object which you touch is unpleasantly cold. The message of heat or of cold is received by the nerve endings in the skin, and is transmitted to the nerve cells of the central station. These cells send out an impulse to the muscles of the arm, which at once move, so that your hand is drawn back from the hot or cold object.

Messages of different kinds are received by different nerve cells. The cells which receive the heat messages are different from those which deal with messages of hunger. But in every case the message is sent from a nerve ending along a nerve fibre, and is received and replied to by a nerve cell. The messages

which are thus received at the central stations are called *sensations* or *feelings*. These sensations may be painful, as in a feeling of great heat or cold or hunger, or they may be pleasant and agreeable, as when we are comfortably warm, when we eat something good, when we look at something beautiful, or when we listen to good music.

Every day and all day long we are receiving sensations through our nerve fibres. They pour in upon us—sensations of hunger and thirst, of heat and cold, of sight, of taste, of hearing. From these sensations we gain all our knowledge of the world without: they tell us of the needs of our bodies; they warn us of dangers; they give us endless pleasure and delight. The unpleasant sensations warn us that something is wrong, and if we are wise we give heed to those sensations and have things put right, and thus the health of the body is promoted and the unpleasant sensations are got rid of.

This does not mean that it is a wise rule of life to choose pleasant sensations before everything else. There are many times when we must give up pleasant things and face things which are decidedly unpleasant at first if our body is to be strong and robust. There are occasions when we must choose between a pleasure which we know to be wrong and a disagreeable duty which we know to be right. A boy who stays lazily in bed when he ought to be up is certainly enjoying pleasant sensations of warmth and comfort, but he is losing an opportunity of improving either his body or his mind. A girl who indulges in too much sweet or rich food is enjoying pleasure from the sense of taste, but she may be injuring her digestion and so preparing the way for very different sensations by-

and-by. In most cases, however, our disagreeable sensations serve the purpose of protecting the body from harm, and our pleasant ones indicate that things are going well with it.

All the sensations we have mentioned are nerve messages of which we are *conscious*. We *know* when we are hungry, or when we are in pain, or when we hear melodious sounds or see beautiful sights. There are other nerve impulses passing from one part of the body to another which we know nothing about, but which are of the greatest importance for the well-being of the body and even for its life. It is impulses of this kind that cause the movements of breathing, and keep the heart beating and the stomach digesting and all the organs acting which carry nourishment from our food to the tissues and remove the waste matter. So long as we are in health all these impulses and movements go on without our knowing anything about them, and indeed we are hardly conscious of having a body at all. If we are ill, we may become conscious of the beating of the heart or the movements of breathing, but we cannot send any message to alter these movements. As long as life continues, there are thousands of those nerve impulses being sent out to all parts of the body by this wonderful telegraph system of ours with which our will has nothing to do.

We must now learn something about the various parts of this system. We must see what nerves and nerve cells are like, and how they carry on this unceasing task of superintending and directing all the varied activities of the body.

The nervous system consists of three main parts—(1) the brain, which is enclosed within the skull; (2) the

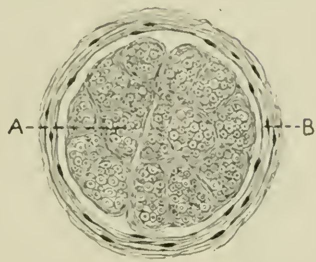
spinal cord, the long tail-like structure which passes from the base of the brain down the canal of the backbone; and (3) the nerves or actual fibres which run from the brain and the spinal cord to all parts of the body. The brain and the spinal cord form what we may call the central stations, and the nerves are the wires leading to those nerve endings which we have compared to the stations where messages are received.

The general arrangement of the nervous system.

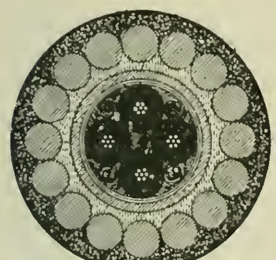
Messages are being constantly sent in to the central stations. The simpler messages are dealt with by the centres in the spinal cord and the lower parts of the brain. The more difficult messages, especially those requiring judgment, and will, and experience, and memory, are passed up to the brain to be dealt with and replied to there.

We shall pass over the nerve endings or receivers of messages at present. They differ so much from one another that we shall have to study each kind separately. The nerves or connecting wires are of two kinds—those

which carry messages *inwards* to the centres in the spinal cord and the brain, and those which carry impulses or orders *outwards* from these centres. A nerve trunk looks like a white cord. This cord is like a telegraph cable, being made up of a large number of separate wires or fibres. Usually there are both ingoing and outgoing fibres in the same cord, but each class of fibres transmits messages only in one direction. These cords or nerve trunks vary much in thickness. The largest is one which passes down the back of the leg; it is as thick as your finger. The trunks divide and subdivide, giving off fibres to each part of the body, until they become so small that they cannot be seen by the naked eye.



Section of a nerve trunk. In the inner portion (A) *each small circle is a separate nerve fibre. Note how all are bound together by the strands of fibrous tissue* (B).

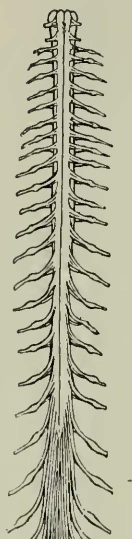


Section of a telegraph cable. The groups of small white wires near the centre represent each a "nerve." Note the layers of material and the thick outer wires for insulation and protection.

Many of the nerve fibres are surrounded by a thick white sheath. This is supposed to act like the insulating material which we put round the wires in a telegraph cable, and which prevents the electric current from passing across from one wire to another; it keeps the message or impulse flowing along the same fibre all the way till it reaches the nerve centre. Thus

every message which comes through a certain fibre must come from the same part of the body.

The nerve fibres simply play the part of connecting wires, carrying an impulse from a certain nerve ending to a certain nerve centre. It cannot do anything else. And as it never does anything else, every impulse which it brings is taken by the brain as coming from its own particular nerve ending. Sometimes this leads to a curious result when part of a limb has been lost. A soldier, for example, who lost his right leg in battle twenty years ago may tell you that he feels the toes of his right foot cold or painful. If there is any irritation at the stump where the nerve trunks were cut off, and this message of discomfort comes to the brain through nerves which formerly had their ends in the toes, the brain still receives it as a message from the toes.



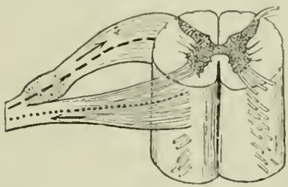
The spinal cord and nerve roots, back view.

No one knows exactly how a message travels along a nerve, or what change takes place in the nerve to pass on the impulses to or from the nerve centre. It is not an electric current; it travels too slow for that. A nerve impulse travels at the rate of about one hundred feet per second, but an electric current travels very much faster.

The *spinal cord* lies in a canal in the backbone or spinal column. It is a thick cord of nerve matter, and gives off thirty-one pairs of nerves to various parts of the body. At the part where most nerves branch off—those going to the arms and those going to the legs—

the spinal cord is considerably enlarged. The cord is covered by two membranes, and the space between these membranes is filled with a fluid which acts as a cushion and prevents the cord from being jarred by sudden movements of the body. It is protected by the projecting parts of the bones of the spinal column, which form a canal for the cord to lie in.

When we examine a cross section of the spinal cord, we see that it contains two kinds of matter which differ in colour. In the centre is a column of grayish matter, or rather two columns, one to the right and the other to the left, connected by a bridge of the same material. The spinal cord is almost divided into two equal parts, lying side by side and joined where they touch each other. Surrounding this central column of gray matter is an outer zone of white matter. When we examine these parts with a microscope, we find that the gray matter consists of cells and the white matter of fibres. Towards the front of the cord the cells are large. These are the cells that regulate movements.



Section of spinal cord, showing gray and white matter and the double nerve roots with outgoing and incoming fibres.

At its upper end the spinal cord passes up into the skull, and becomes much thicker. This thickened portion, which is called the *medulla*, is really a part of the brain. It is very like the spinal cord in structure, however, only the gray matter is not grouped into a double column, but is scattered in irregular masses.

The work done by the spinal cord and the medulla is of two kinds. They contain, as we have said, the lower

and less important nerve centres to which messages are sent, and they also contain the main trunk fibres by which messages are transmitted to the higher centres in the brain. In simple matters they act on their own account, sending back impulses in response to messages received. Other messages they send on for the brain to deal with, and transmit the reply of the brain to the parts of the body concerned.

The chief function of these lower centres is to control what we call *reflex* movements. Let us see what a reflex movement really is. When you place your hand on something very hot, you pull it away immediately. You have done this almost before you are aware, and certainly without stopping to think about it. You do not say to yourself, "This metal is very hot. It is so hot that it will cause a burn. Burns are painful things, and I wish to avoid the discomfort and pain of a burn. I think I had better remove my hand." If you went through such a process of deliberation, your hand would be burned long before you moved it away. Nature has provided a shorter way of safety. Let us see how.

In the first place, a painful sensation of heat passes from the nerve endings in the skin of the hand along the nerve fibres, and reaches the spinal cord. Immediately an impulse is returned from the large cells in the front part of the cord to the muscles of the arm, causing them to remove the hand from the hot substance. This seems to be instantaneous, but there is enough time for the two messages to be sent and received. This, then, is an example of reflex action. The message is *reflected* or turned back to the muscles.

Reflex action plays a very important part in the body, and it is easy to find examples of it. When

something is brought close to the eye, you close the eyelid at once; you can scarcely help doing so even when you try. This is a reflex action designed to protect the eye. When a crumb gets into the larynx, you cough. This is a reflex action for the purpose of removing the irritation and protecting the air passage. The reply message in a reflex need not be an impulse to perform muscular movements like these. It may be a stimulus to glands or to blood-vessels. The glands may be stimulated to secrete, or the blood-vessels to become flushed with blood.

Reflexes differ from other actions in not requiring to be learned. They are scarcely improved at all by practice. A baby attracted by the brightness of a flame stretches out his hand to grasp it, and when he feels the heat he pulls away his hand quite as well as he will ever do. You have heard the old Scottish proverb, "Burnt bairns dread the fire." What "burnt bairns" learn is that fire is hot; they do not need to learn to pull away the hand when they feel heat.

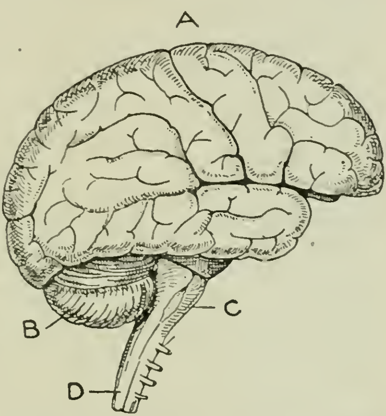
The reflexes concerned with the heart movements and with breathing are controlled by cells in the medulla. These movements must be carried on without our knowledge or direction, because they are necessary at the very beginning of life, and must continue without intermission all through life. All the cells in the spinal cord and the medulla have some special work to do. Those in the medulla, as we have said, control the circulation and respiration. The cells in the upper part of the cord preside over the arm. The lower part controls the leg. When the lower part of the cord is injured, as has sometimes happened in a railway or other accident, the legs cannot be moved. If

the cord is injured in the neck, both the arms and the legs are powerless. If the medulla is destroyed life ceases, for the movements of the heart and of respiration cease.

CHAPTER XIX

THE NERVOUS SYSTEM—II

We have now to consider the main central station of the nervous system—the part which controls all the activities of the body. That is the *brain.* The brain is enclosed within the skull, a strong box made of bone to protect the delicate nervous structure. The brain is covered with two membranes similar to those of the spinal cord, and between these membranes is a fluid, forming a water bed for the brain to rest on and so protecting it from jolts and jars.



Side view of the brain. Note the cerebrum (A), *the cerebellum* (B), *the medulla* (C), *and the spinal cord* (D).

A side view of the brain shows that it consists of two main parts. The upper part, which is called the *cerebrum,* is much the larger of the two; the smaller part, the *cerebellum* or little brain, lies below the hinder part of the cerebrum. If we look at the brain from above, it appears to be a double organ, consisting of two hemispheres, a right and a left.

The brain is an organ of considerable size, being about three pounds in average weight in a man. The size varies considerably, and the work which the brain can do depends not merely on its bulk but also on its quality. Some men of great mental power have had a very large brain, however; Cromwell's brain is said to have weighed five pounds. On the other hand, many men of genius have possessed a brain of less than average size. A large head does not necessarily show that the brain is also large.

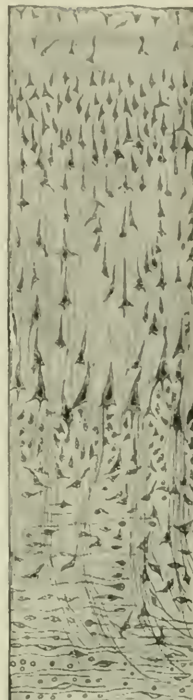
Nerve cells from the cerebrum.

As the brain is the organ most closely connected with thought and sensation and feeling, and with the control of movements, it is natural that the human brain should differ considerably from that of any of the lower animals. It is very much larger in proportion to the weight of the body, and it is much more complex in its structure. A whale, for instance, may be over fifty feet in length and its weight may be reckoned in tons, but its brain is less than double the weight of a man's brain.

Nerve cells from the cerebellum.

The outer surface of the brain is much folded and wrinkled. This is a very important fact, and we must try to understand what it means. Nerve tissue, as we

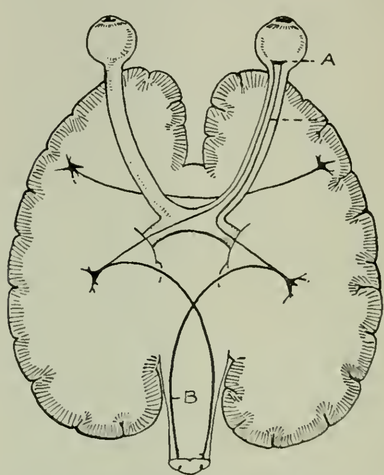
have seen, is of two kinds—nerve cells and nerve fibres. The cells are the centre of force and power, and from them comes all the energy that is needed for receiving sensations and for sending the stimulus which makes our muscles act. The transmission of all such stimulus depends upon the action of the nerve fibres. The workman who is digging a trench, or hammering in nails, is able to do his work only so long as his nerve cells and fibres act well together and guide smoothly the action of one muscle after another. It is equally true that it is through the harmonious action of nerve cells and fibres in the brain of our statesmen that the Dominion and the Empire are governed. The direction of any business enterprise depends upon the vigour of the cells and fibres in the brain of the manager.



A section through the gray matter of the brain. Note the different shapes and sizes of cells at different depths from the surface.

In the spinal cord and the medulla we saw that the nerve cells, the centres of energy, occupy a place in the middle. In the brain, however, the cells form a layer on the outside, and the surface of the brain is its active part. For the production of a great deal of nerve energy, therefore, the brain must have an extensive surface layer of cells. A brain of a lower type, which has less work to do, does not need so many cells, and a smaller surface is sufficient.

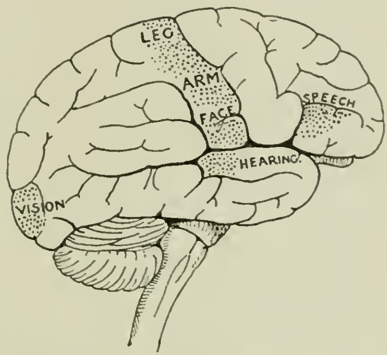
In the human brain the layer of cells is very extensive—so extensive, indeed, that it cannot be spread out smooth inside the skull, but is crumpled and folded. If your handkerchief were small enough, you could put it into your pocket without creasing or folding; as it is, however, you must crumple it up before it will go in. This is the cause of the wrinkles in the surface of the brain; the folds or convolutions are due to the extent of that surface being much greater than can find room in the skull in a smooth or unfolded position. In the lower animals, where fewer brain cells are required, the surface of the brain is comparatively smooth.



Some fibres connect different parts of the brain, some pass to the spinal cord (B), *and some to the eye* (A) *and other parts of the body.*

The outer portion of the brain, then, consists of this huge folded surface composed of layers of nerve cells. Its inner portion is made up of nerve fibres which spring from these cells. The fibres run in various directions. Some of them connect different parts of the brain with one another. Others pass down into the spinal cord. Others, again, form the nerve cords which go to the eye, the ear, and other parts. In the brain as elsewhere the nerve fibres are merely wires to conduct messages and impulses inwards and outwards. The

cells, on the other hand, have many and varied duties to perform. One of the most wonderful things that has been found out about the brain is the division of labour among its various parts. Certain of its cells are set apart for doing certain kinds of work. We do not use the whole brain for seeing, or for hearing, or for thinking out a problem. One group of cells is concerned with vision and with nothing else, another with taste alone, another with hearing alone, and so on throughout all the various groups of cells.



Parts of the brain which are connected with movements of certain parts of the body.

This division of labour, or assigning to each part its special work, saves much effort in the various parts and increases the efficiency of the whole. The government of a great city or country could not be efficient if each official tried to take part in every kind of work. In a city we have certain officials who look after the water supply, others for the gas or electric lighting, and others for the care and cleansing of the streets. In the government of a country there are ministers who are entrusted with each department of the country's affairs—its education, its agriculture, its navy and its army. So it is in the brain. The different kinds of work to be done are controlled by groups of cells in different parts of the brain. It has been discovered that certain areas of its surface are connected with the

movements of certain parts of the body, but much is yet unknown regarding its organization.

We know most about the cells which regulate movements, and from these we may learn something about how the brain works. When we write, for example, we use the right arm and hand. In order to move these in the required way, we send impulses from certain cells of the brain to the various muscles. The impulses pass down to cells in the spinal cord, and from these along the nerve trunk which contains the nerve fibres of the arm and hand. Thus each nerve carries the stimulus to its own muscle, and the muscles, contracting in the proper order and to the proper extent, move the hand that holds the pen so as to trace out the form of the letters.

The brain has not only to send out impulses; it also receives messages. Some of the receiving stations, such as the nerve endings of touch, send their messages first to the spinal cord and then on to the brain. Some nerves, such as those of sight, hearing, smell, and taste, carry their messages direct to the brain. The fibres which link one part of the brain to another provide for our acting in accordance with these incoming messages. Thus the messages of sight which we receive while learning to write guide us in sending out the proper movement impulses to the hand, and so we can make letters of the same size and shape as those which we are copying.

We do not understand fully the work which is done by the cerebellum or lesser brain, but we know that it has something to do with our being able to combine our muscular movements, as we must do in keeping our balance when standing or walking.

The cerebrum or great brain is the organ on which consciousness depends, and through which we become

aware of ourselves and our surroundings. If the blood supply is cut off from the brain, it cannot act, and we lose consciousness, as we say. We no longer know where we are or who we are or what is happening around us. Consciousness depends on brain activity, and brain activity depends on blood supply. Certain drugs hinder the action of the brain cells by poisoning them. When a man takes a considerable quantity of opium or of alcohol he becomes unconscious, through the poisoning of his brain cells.

From these facts we learn the chief laws which we must observe if we would have a healthy brain. First, we must keep it supplied with plenty of blood—good, pure blood, which is made from good food and fresh air; and, second, we must avoid poisoning the brain cells either with bad air or with alcohol or other drugs.

We have now to mention a part of the brain's work which is perhaps the most important of all. We have seen that the nerve centres of the spinal cord and the medulla direct many of our reflex movements. An incoming message is answered by an outgoing stimulus. There is no thinking over it and deciding how to act. Sometimes the brain centres work in this way too. A man sees a certain opportunity and feels a certain desire, and at once he acts so as to gratify his desire without thinking about it, although he may know quite well that it is foolish or wrong to act so. Now, one of the most important powers of the brain is just the power of *not acting*—of keeping back an outgoing impulse until we have deliberated and decided what is best to be done.

This power of *self-control*, or of selecting and restraining action, is situated in the brain alone, and it

is the strength or weakness of this power which really stamps any brain as good or bad. A man may be an able scientist or an eloquent speaker or a skilful artisan, but if his brain is not trained in self-control, if he cannot restrain hasty action and choose what is right and good, he has not the finest type of brain. This power of self-control and deliberate choice comes only by exercise and practice. By consciously and deliberately choosing the best, and refusing to act on hasty impulses, we can train our brain, just as by exercise of another kind we train our muscles.

How can the brain be trained to act in a certain way? It depends on this fact, that when certain cells have once acted together, or one after the other, it is easier for them to act in this way again. Then every time the action is repeated it becomes still easier. That is what we mean by the proverb, "Practice makes perfect." If it were not for this, our lives would be very different; the man would have no more skill than the baby. If you wish to be a good pianist, you know that you must begin young and you must be willing to spend several hours a day in steady practice for months and years. If you want to excel in any game, you must not only study how to make the right movements at first, but you must also practise them, and go on repeating them again and again until they become easy and can be quickly and accurately made. In all learning the same rule holds good. When you have learned to read any new language, such as French, a page of that language looks very different from the puzzling and unmeaning thing it once was.

In all such cases, the cells in the brain have been trained by practice to work in a certain way. Almost everything we do, in fact, comes to be a *habit* learned

by the brain, whether it be a bodily or a mental habit. This enables us to cultivate and to confirm any habits that we know to be good, and good bodily habits are those which promote health. We must form the habit of eating at regular times, of breathing fully and deeply, of sleeping at the right time and sleeping soundly, and thus train the brain cells to do their proper work in managing the body. We must also form good habits of thinking and of study, so that we may get the best work out of our brain cells.

There are some golden rules for the formation of good habits which we ought to observe. The first is to learn correctly from the beginning. If we begin to speak French or German with a bad accent, we shall never speak it well. If once we get into the habit of sitting all evening over our lessons in an easy-going way instead of studying hard and getting them finished, we shall find it difficult in after life to bend our minds to any stiff piece of work we may have in hand. If we sit in a bad position, with shoulders rounded and chest cramped, we shall find it very hard later to give this up and sit in a good position.

The second rule for training the brain in good habits is not to be discouraged and give up trying before the brain cells have learned what we set out to teach them. "If at first you don't succeed, try, try, try again." It is only at the beginning that the work is difficult. We are sure to succeed if we keep on trying. And our brain is so made that when we have succeeded, the cells never lose what they have learned. They keep the power which they have acquired.

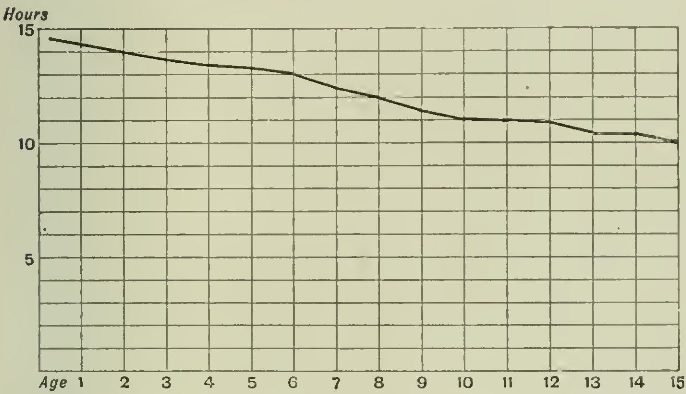
Indeed, when we have learned a thing thoroughly, the nerve cells practically take charge of it and look after it for us without any attention or effort on our

part. Every girl can remember what difficulty she had at first in learning to knit. The knitting needles seemed so long and were so easily dropped, the wool always got into the wrong position, and the stitches would never look regular. But now it is all different. She simply starts her knitting, and it goes on. She hardly needs to give it any attention, and her mind may be attending to other things all the time; some girls, indeed, can read a book while they are knitting, only giving an occasional glance at the work. The brain cells go on directing the fingers in the movements which were once so difficult and needed so close attention. When we once learn to ride a bicycle we do not forget the art even if we should give up the practice of it for a time. If we have learned to swim, although it should be long ago, it is only necessary to jump into the water, and the nerve cells at once take up their old work of guiding the movements of the limbs. One who has mastered any foreign language in youth may forget it for a time and may feel somewhat helpless on hearing it spoken again, but soon the nerve cells resume their former mode of action, and the language "comes back," as we say.

The brain cells, then, go on accumulating and storing up all those vast numbers of habits of action and of memory, and yet all day long there are fresh showers of messages streaming in and replies being sent out. There are messages of sight, of hearing, of taste, and of smell; messages from the skin, from the muscles, and from the glands; messages of cold, of warmth, and of pressure. Some of these messages give rise to pleasure, others to discomfort. The kind of feeling which accompanies the messages has a great influence upon the action of the brain. When one is cheerful

and happy, all the activities of the body tend to be carried on vigorously and well. When one is dull and depressed, all the functions of the body are sluggish. So there is some real practical wisdom in the old proverb, "Laugh and grow fat."

In view of the countless number and variety of messages which the brain cells receive and send out, it is not strange that they should get tired sometimes.



This diagram shows the amount of sleep required by children up to the age of fifteen.

When we have done a great deal of study or of any kind of work our brain does get tired. Exhausted or overworked brain cells differ, even in outward appearance, from those that are fresh. A tired nerve cell, like a tired muscle, needs rest, and this rest is best obtained in sleep. When we fall asleep, the action of the nerve cells becomes quieter, until we are quite unconscious.

How do we go to sleep? Perhaps we have never thought of it before, but if we consider it, we shall see

"*Tired brain cells*" (p. 229). *The Earl of Argyle, condemned for rebellion against James II., was found sleeping peacefully when about to be led out for execution.*

that we begin by shutting off as many as possible of the incoming messages which usually pour into the brain. We shut off messages of sight by sleeping during the night-time, in a room without lights, and by closing our eyes. We choose a quiet room for a bedroom, so that no incoming messages of sound may keep the brain active. We undress in order that there may be no messages of discomfort due to the unequal pressure of our day clothing. We cover ourselves with comfortable bed-clothes, so that no messages of cold may keep the brain awake. The comfortable warmth of the bed makes the blood flow freely to the skin, and so the quantity passing through the brain is lessened; and we have already seen that with a small blood supply the cells become less active, and unconsciousness is more easily produced.

The best way to prepare for sleeping well is to have plenty of work and play during the day to make us tired. We then lie down in a quiet, dark room, neither too warm nor too cold. If one is very tired, he may sleep even in a bright light and among loud noises. Soldiers have been known to fall asleep from sheer fatigue though cannon were booming all round them. In the matter of sleep, as well as in other things, the brain cells can adapt themselves to their surroundings. Tired brain cells can accustom themselves to sleep among the noises of a great city. Some city people are so used to the noises of the busy street that they cannot sleep well in the country at first because it is too quiet. Since the brain is so ready to form habits, we should see that the habits we learn are those which will give our brain thorough rest and prepare it for doing good work. When we wake up in the morning we can easily tell whether we have slept well; if our

brain is rested, we feel refreshed and alert, and eager to begin the activities of the new day.

Some useful rules for sleep are these: (1.) Sleep in plenty of fresh air, with the bedroom window wide open if possible. (2.) Sleep regularly; go to bed at a certain hour and get up at a certain hour. (3.) Go to bed *meaning* to sleep at once, and do not allow yourself to think or worry over things. (4.) Have your bedroom dark and as quiet as possible. (5.) Use light but warm night garments and bedclothes.

While children are growing, more rest and sleep are needed than afterwards. A doctor who has studied this matter with much care tells us that, in order to give the body a proper chance of developing and growing strong, a child under six needs thirteen hours' sleep daily, a child of eight should have twelve hours' sleep, and at the age of ten eleven hours' sleep is required.

CHAPTER XX

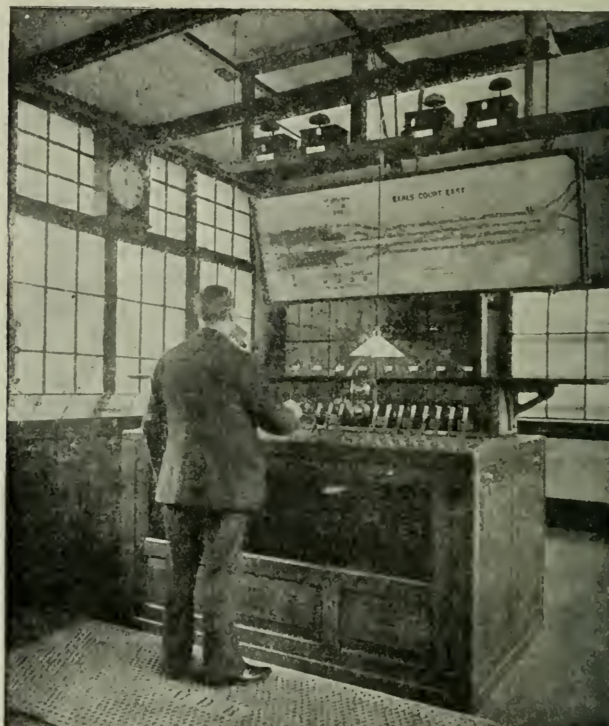
SELF-CONTROL

Have you ever lived near a railway line? If not, you may have had to wait for a train at some busy station. It is very interesting at such a place to watch the trains that pass. There are express trains that thunder past without stopping, slow trains that stop at every station taking up or setting down passengers, and freight trains loaded with goods from foreign lands, or with wheat to supply the markets of the world.

What confusion there would be and what accidents might happen if there was not some way of regulating all this traffic! How is it regulated? At various places along the line there are erections called signal-boxes, with men in charge of them, and on tall posts there are signals for the driver of the train to see. The signalman must show a certain signal to let each driver know whether his train may pass or not. If a certain kind of signal is shown, even the fastest train must stop. Any mistake made by the signalman might lead to a very serious accident—if, for instance, he were to give an express train the signal to pass while there was another train on the line in front of it.

There is something in the body which we may com-

pare with this. All day long messages and impulses are being sent along your nerves just as the trains are sent along the railway lines. Some of these im-



In a railway signal-box. Note the levers for working the signals, and the plan of the railway lines in front of the operator.

pulses are good, and should be allowed to pass. Others are harmful, or are trying to pass at the wrong time, and these must be stopped. Now you have already learned that there is in your brain an arrangement which allows you to stop the harmful impulses, just

as the signalman stops a train. This is called the power of *inhibition*, which is just another name for the power of saying "no" to any impulse, and preventing it from acting.

Let us take an example. If a boy strikes you, there is a natural impulse which tends to make you strike back. But if for some reason you prevent this impulse from acting, you stop the stimulus which would be sent to your arm just as the signalman stops a train and delays its passing. Or, perhaps, when you are called in the morning there is a lazy impulse about to be sent which will make you roll over on the other side for one more nap; you may stop this impulse, and pass on instead the impulse which will lead to your getting up.

You have also learned what we mean by the law of habit. The oftener we do a thing, the easier it becomes. You find this when you are learning to read, or to skate, or to swim. At first the movements needed are extremely difficult, but by-and-by they become quite easy. In the same way we find it hard at first to say "no" to an impulse which we would like to gratify, but if we go on checking such messages time after time, it becomes quite easy. And when we have learned this lesson, we have gained something which will be of great value to us all our lives: we have gained the power of self-control.

Have you ever noticed a footpath crossing a grass-plot or a pasture field? How was that path formed? Some one crossed the grass in that direction one day, but his feet left no mark. Many people used the same short cut, and by-and-by one could see that the grass was being crushed down and the soil was being beaten hard, and so the footpath was formed.

The same kind of thing happens in our brain. If we do a certain thing or act in a certain way time after time, a path gets beaten out in the brain, and our action tends to follow that path ever after.

We must be careful, therefore, to see that the paths which are being formed in our brain are good paths—that is, to see that we learn good habits. It is always hard to change a habit after it is formed, and as we get older the difficulty becomes greater. Hence, if we are wise, we shall attend most carefully to the formation of good habits while we are young, and to the checking of any bad habits which we know of, before they make the paths in our brain too hard or too deep.

Perhaps you have thought of habits as being concerned only with our manners and behaviour; you know it is a bad habit to slam the door or to leave it open instead of shutting it quietly, and that it is a good habit to say "please" and "thank you" on fitting occasions. But habits are concerned with other things as well, and have important effects upon the preservation of health. There are habits of eating and drinking, for example, which are very important; there are also habits of walking, speaking, sleeping, and even of thinking, which are all concerned with health.

Among the good habits in eating which we should learn and practise, the chief is to take our food regularly. Every organ in the body works best when it works regularly. Irregular meals are a frequent cause of bad digestion. Again, we should form the habit of eating plain and wholesome food. Too much should not be eaten just because a dish happens to please our taste. Children always like sweets, and these are quite good for them if taken occasionally after a meal. The

wrong ways of eating sweets are to take them between meals or just before a meal, to eat so many as to spoil the appetite, or to take them the last thing at night. A common habit in eating is to eat too much. Food is fuel, but a fire does not burn well if we heap too much fuel upon it.

Bad habits in drinking are more common than bad habits in eating. The worst of these habits is that of using alcoholic drinks. You have already learned in an earlier chapter a good deal about alcohol and its effects, but the matter is so important, and so many people make disastrous mistakes in the use of alcohol, that we must mention once more the need for self-control in regard to it. Beer, wines, spirits, and many other common drinks contain more or less alcohol, and this produces a feeling of excitement and warmth in the body for a time. These results do not last, however, and the excitement is followed by depression or lowness of spirit; hence people get into the habit of taking more and more alcohol in order to keep up the feeling of excitement. Alcohol when taken in considerable quantities produces very bad effects upon the body, and destroys all the tissues of which it is composed. Memory and the power of judgment are weakened, and one can never rely upon a man whose body is injured by alcohol. It poisons slowly every part of the body, including the brain, and the finer and nobler parts of the man's character are the first to be destroyed.

It used to be thought that alcohol is useful as a food, but we know now that it is not. No healthy body ever needs alcohol in any form. Experiments have been made to find out whether men work better after taking alcohol, as was often said to be the case. It has been found that things which require skill

Quatre Bras. By Lady Butler.

(By permission of the Fine Arts Society, Ltd., London.)

A fine example of training and self-control. The British squares at Quatre Bras and Waterloo held their position in spite of artillery fire and cavalry charges by the French.

are not so well done after alcohol is taken, and that work requiring strength and endurance can be better done without it. Some boys take alcoholic drinks because they have seen men do so, and think it manly. The more manly way is to avoid forming habits which are always hurtful, and which may become too strong, and thus end in ruin.

Smoking is another common habit which may become a danger to health. Grown-up men who smoke a moderate quantity of tobacco are not injured by it. Boys who smoke always suffer harm. Smoking interferes with the growth of the body, and usually injures the heart. The boy who smokes, therefore, runs a great risk of having a weak heart, which will keep him from ever being a strong, vigorous man. When men are about to engage in some sport which requires special strength or endurance, such as running or rowing, they "train" for it—that is, they take care to make their muscles fit and strong. During their time of training they are careful about the amount and the kind of food they eat, and they neither take alcohol nor smoke tobacco. They know that over-eating, drinking, and smoking would make their muscles less vigorous. We do not all engage in running or rowing races, but we must all work, and we all wish to keep our bodies healthy. It is very foolish, therefore, to learn habits which make the body less strong and less able to do the work which we may need to perform.

There are other harmful habits which we must try to avoid. We all want to live a happy life as well as a healthy one, and it is right that we should do so. One very useful habit for us to form is that of thinking cheerfully. People often say, "We can't help our thoughts," but we really can if we try hard enough.

It is easy to fall into the habit of worrying over things that "can't be helped," or of thinking hard and unkind thoughts about other people; yet such habits can be broken off. The simple rule is, "Think about something else;" and every time the gloomy mood returns, use the same cure—"think about something else." It does not matter very much what the "something else" may be at first. Anything will serve our turn if it

"They take care to make their muscles fit and strong."

breaks the chain of our undesirable thoughts. The oftener we do this the easier it becomes, until by-and-by we find that our ugly habit of mind is gone, and we are once more master in our own house—we can choose the subjects on which we shall allow our thoughts to dwell. This is the only true freedom; there is no slavery worse than that of him who is a slave to his own evil thoughts. The best people in the world are those who have thus learned by practice how to control themselves. This is beautifully expressed in the Book of Proverbs: "He that is slow to anger is better than the mighty: and he that ruleth his spirit than he that taketh a city."

CHAPTER XXI

THE EYE

A FEW friends were spending Christmas together in a country house in England. One evening, after a day spent in active amusement out of doors, they sat talking by a blazing fire, and it chanced that they began to discuss what they would do if they suddenly became very rich, and what they would buy first with their spare money. One man was a keen follower of the old English sport of fox-hunting, and he said he would buy the most splendid horses and ride after the hounds every day when hunting was possible. The next man said he would spend thousands of pounds in forming a library; he would have the walls covered with the rarest books, and the finest editions that money could buy. Next came a woman, who said she longed to possess lovely old furniture and china, and she would spend a fortune in making her house beautiful. Another woman confessed that she would begin by buying beautiful clothes—silks and laces and furs.

So the light-hearted talk went round, each man and woman having a different idea of what would make them happy if only they could afford it. Then the question was asked, what would they do next? After the horses and books and furniture and dresses had been bought and enjoyed, what would each choose as

the second best enjoyment? And then the curious result was that they all agreed upon the same form of pleasure—namely, travel. Next to their own special hobbies, all declared that the greatest pleasure they knew would be to travel and see foreign lands and peoples.

"To see the world!" Who has not dreamed of doing that one day or another? What a fascination it has for boys and girls—especially boys, perhaps! To wander from city to city and see their strange inhabitants and their wonderful buildings; to look upon the great mountains and rivers whose names we have so often heard, or, better still, to look upon others which no human eye may have seen before—for such pleasures as these men have given their wealth and even their lives.

Few of us can gratify this desire to "see the world," for foreign travel requires much time and money. But our eye is not quite shut out from this kind of pleasure. We may never see the Rhine, but we can feast our eyes upon pictures of its terraced vineyards and its castled crags. We are more fortunate in this than our ancestors were, for by the art of the photographer, and by means of the optical lantern and the cinematograph, we may enjoy at second hand hundreds of sights which our eyes will never behold in their actual and present reality.

When we do travel abroad, and pictures of new places and strange scenes delight our eye, we often carry with us a camera and take many "snapshots" of what we see, so that when we are back in our home again we may have the power of recalling more vividly what we see and enjoy. The real scene will be far away, but the photograph will call it up again in our

"*The picture which your eye received while you were there*" (p. 247). [*The Falls of Niagara.*]

imagination, and will also help in some degree to make our friends see what we saw upon our travels.

The photographic camera is a useful servant of the eye. But perhaps you do not know that the eye and the camera are very like each other in their structure and their way of dealing with the light which makes up a picture. When you look at anything you turn your eyes so that the light enters and makes a picture of the object at the back of your eye, and this picture is somehow impressed upon the brain, and thus you *see*. In the camera, light from the object enters and makes a picture upon the screen, or upon the sensitive plate or film which you put in to receive it; you "develop" and "fix" this picture made by the rays of light, and it becomes permanent. The eye is a living camera; the camera is a mechanical eye.

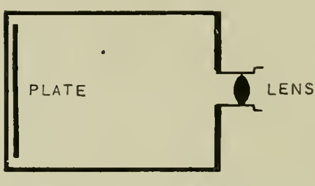


Diagram of photographic camera. Note the lens in front and the plate at the back.

The word *camera* means a chamber or room; the full name is *camera obscura,* which means a dark chamber. The photographic camera is a box into which no light can enter except through the opening in front where the lens is placed, and this opening can be closed by means of a shutter. It has also an arrangement which we call a diaphragm or stop for making the opening smaller or larger according as the light outside is strong or weak. The inside of the box is black, so that no stray beams may be reflected from one part of it to another. The lens bends the rays of light which we allow to enter so that a clear and sharp picture may fall on the plate at the back of the camera. This plate is coated with a specially prepared

substance, on which every ray of light leaves its trace, and so the picture which falls on the plate can be caught and preserved.

The arrangement of the parts of the eye we shall find to be very like that of the camera. It is round in shape, which is much more convenient than if it were square; but like the camera, it is dark inside. Light enters only at the front opening, where we shall find a shutter, a lens, and a stop, and the light paints a picture upon a wonderful screen at the back—more wonderful than even the sensitive plate of the camera.

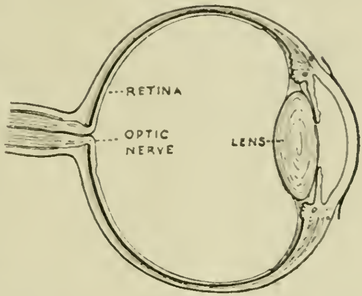
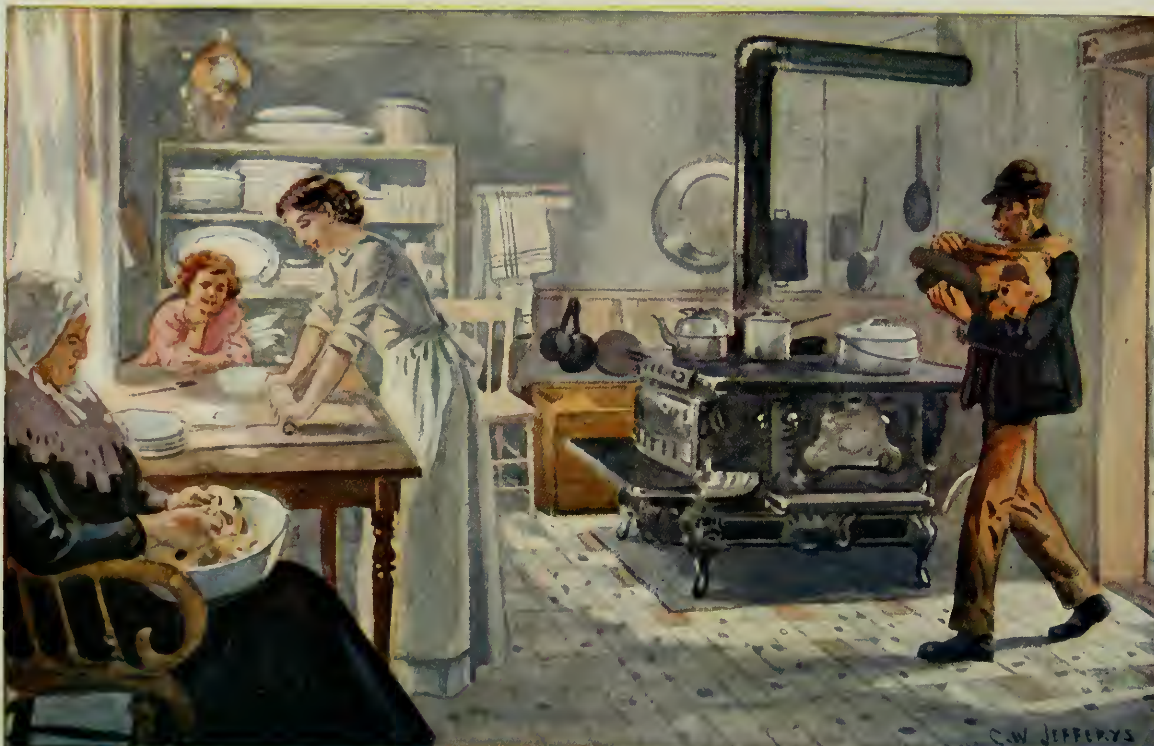


Diagram of eye in section. Compare position of lens and retina with the photographic camera.

The eye is a very delicate structure, and must be carefully guarded from injury. It is placed in a bony socket in the skull, which protects it on every side except in front. There it has the protection of the *eyelids*, which act as a defence from injury and as a shutter to keep out light. The eyelids have a fringe of hairs called the *eyelashes*, which help to keep out dust from the eye. If you watch carefully the eye of a friend, you will see that the eyelids are never long still. Every few moments they move quickly over the eye, shutting and opening again so

External view of eye.



"The best kind of memory pictures" (p. 253). [*A Canadian Kitchen, by C. W. Jefferys.*]

quickly that the person is scarcely aware of the movement. This frequent winking of the eyelids keeps the front of the eye free from dust.

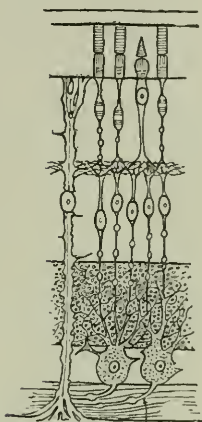
The *tears* also cleanse the eye. This does not mean that you must cry now and then in order to keep the front windows of your eyes clean. Even when you are perfectly happy there is a small quantity of water flowing over the surface of the eye. It is produced by a gland in the corner of the eye, and escapes by a small pipe or canal into the nose. What we call "tears" is the overflowing of this water, when the gland is irritated or stimulated so as to produce more than the canal can lead away into the nose.

The eye itself is, as we said, a round box. The covering of this box is quite firm. It is white in colour except in front, where it is clear or transparent, to allow the light to enter the eye. This white covering has a black lining inside, just as a camera has. Towards the front, where the white wall of the eye becomes transparent, this black lining changes into the coloured curtain which you see through the clear part of the eye. It is this curtain which gives its colour to the eye. When a boy has dark brown eyes, it means that there is a great deal of colouring matter in his eye-curtains; if he has blue eyes, there is less colouring matter present.

On account of its colours and its shape, this curtain is called the *iris*, which is the Latin name for the rainbow. Its use in the eye is much the same as that of the stop or diaphragm in the camera. The round opening in the curtain is called the *pupil*. When the light is bright, the opening contracts so that too much light may not enter the eye. When the light is dim,

the curtain is drawn back a little so as to leave a larger opening.

Close behind the curtain is the *lens* of the eye. It is made of a clear glass-like substance which bends the rays of light just as the lens of a camera does, and makes them meet so as to form a distinct picture. The space behind the lens is filled with a clear watery fluid.



Section through the retina showing the special nerve endings above and nerve cells below, with fibres passing to the optic nerve.

At the back of the eye, spread over the dark lining, is the sensitive screen upon which the picture is formed by the light. This screen is called the *retina.*

The retina is the part which receives all messages of sight and transmits them to the brain. It consists of the nerve endings of the nerves of sight, which are specially adapted to receive messages of sight only. When a picture falls upon the retina, nerve messages are sent to the brain from all the parts of this screen on which rays of light are falling, and these messages are received by the brain cells, so that we become aware of them, or "see" the various parts of the picture.

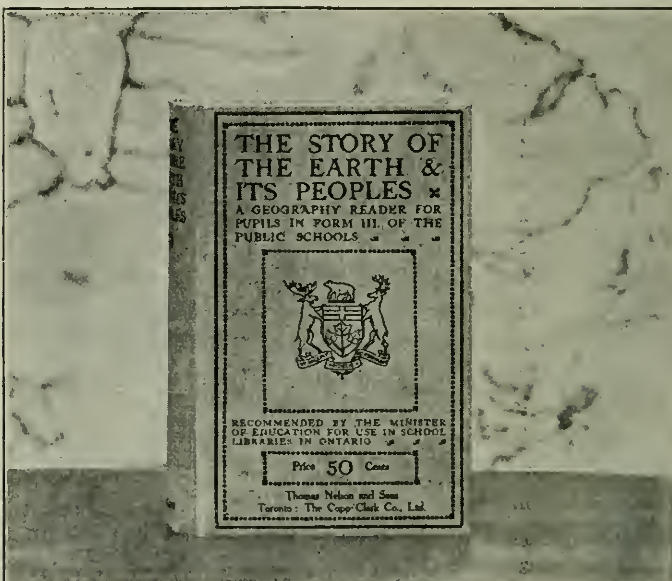
In the camera we put a sensitive plate on which we can "fix" the picture, and we can take copies of this and look at them when we please. In the eye, however, when we close the shutter, the picture is gone; or when we turn the eye from one thing to another the scene changes from moment to moment as on a cinematograph screen, and no trace is left behind upon the retina. But the picture is not really gone. It is stored

up in some mysterious way, and can be thrown upon the screen of memory by the action of those wonderful cells in the brain.

Suppose that you have been to see the Falls of Niagara, and after you come home some one asks you what they were like. The question calls up in your mind the pictures which your eye received while you were there. Again, in memory you walk up along the side of the river, and you behold that ceaseless flood of water pouring down into the foaming gulf below. You see the columns of white mist arise, with broken patches of rainbow gleaming here and there upon them, and the eddies of green foam-flecked water where the tiny "Maid of the Mist" puffs and struggles against the current. Your memory becomes a cinematograph screen, and it is a screen which not only displays the pictures again, but also arouses those feelings of admiration and wonder which the stupendous sight called up in your mind. You forget for the time the pictures which are now falling upon your retina. You may even close your eyes as you think upon that wonderful scene, in order that nothing may distract your attention from your memory pictures. This is one of the best uses of a holiday—to store the memory with pictures which will remain with us all our life, and enrich our mind with a private picture gallery of our own. And since those pictures remain in the very fibre of our brain, and are ready at any time to throw themselves upon the screen of memory, we should be very careful to avoid all pictures of evil and wrong-doing which would spoil our collection, and make our picture gallery a source of pain rather than pleasure.

If you have a camera of your own, or if you have ever helped to take photographs, you know what a

trouble it is sometimes to get the picture sharp and clear. Things which are too near the lens are blurred and indistinct. When you alter the position of the lens so as to "focus" these and make them clear, the more distant things become blurred. The eye must "focus" the objects in its picture too. We can look



In this photograph the book is in focus and the map behind it is indistinct.

at the book in our hand and see every letter on its page clear and distinct. We can then look past the book to the other side of the room or of the street, and see that distinctly. But we cannot see both clearly at the same time. When we look out of the window over our book, the book is blurred and indistinct; and when we look at the book, the distant view is out of focus. But we

have no trouble with the focussing. The eye adjusts itself at once to the distance of the object without our knowing anything of the change. It is only when we try to look at a thing too near that we have an uneasy feeling in the eye as it strains to alter its focus. The focussing is done by small muscles within the eye.

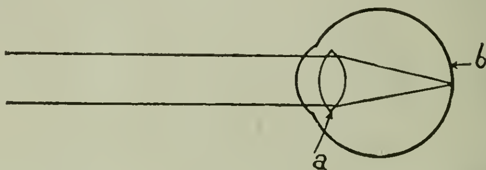
In this picture the map is in focus and the book is indistinct.

There are also muscles attached to the outside of the eye by which we can turn it upwards or downwards, and from side to side, without moving the head.

In the camera we can take only one picture on each plate. On the retina, as we have seen, an infinite number of pictures are falling throughout our waking hours, and each of these is passed on by the nerves to

the brain. The retina does get tired at times, but all that it needs to restore it is a short rest with eyes closed, or, better still, a sleep. Then it is ready once more for the endless stream of pictures which pour in upon our vision.

Perhaps you have thought of one difference between the pictures on the retina and the pictures in a camera—the eye takes all its pictures in colour, and not in mere black and white. But the picture in the camera is in colour too, as you may see upon the screen



How rays of light are bent by the lens of the eye (a) *and focussed on the retina* (b).

of a focussing camera. The pity is that we have not yet found a really satisfactory way of fixing those colours upon the plate. Some day, perhaps, one of you may invent a simple way of preserving upon the photographic plate all the colours that the light paints there, just as your memory pictures preserve not only the outlines of what you see but all the wealth of colour which the eye beholds.

Since the eye is of so much use to us, and is also a very delicate organ, it is important that we should take good care of our eyes, and avoid anything which would injure them or spoil their power of seeing. You know that many people wear glasses of one kind or another. Old people usually need glasses, because the eye changes when one gets old and cannot focus near objects so well. Many children need glasses. All eyes do not focus

equally well or with equal ease, and there are some people who do not see so clearly as others when looking at things that are either close at hand or far away. In such cases we can make the work of the eye more easy by letting the light pass through a glass lens before it reaches the lens of the eye, and thus giving the eye less to do in bending and focussing the rays.

"*It is very bad for the eyes to have a strong light directly in front*" (p. 252).

Glasses of the right kind give much help to the eye, but those of the wrong kind are very harmful. It often happens that a person has one eye weaker than the other, and that each eye needs a different kind of lens. It is a very difficult matter to tell exactly what kind of glasses will help one whose sight is not good,

and only those who have studied the subject are able to advise us about it. Before using glasses of any kind we should consult a doctor who has made a special study of the eye.

Sometimes the eye is injured by things getting into it, or is entirely destroyed by some accident. In our games we should avoid any rough play which might cause injury of this kind. We ought never to throw anything in the face of a companion, or to strike one in such a way as to endanger the eye. Serious accidents often happen, even at school, through careless or rough play and without any evil intention.

But boys and girls usually do more harm to their own eyes than to those of their companions. They often sit reading in a bad light, or they lie on a couch or a chair with their head leaning in an awkward position, so that the eye cannot easily follow the lines on the page. People often sit reading in a dim light rather than trouble to move nearer the window or to light the gas. When writing it is still more important that we should have the light falling properly upon the page. The light should come over the left shoulder, so that we do not see any shadow cast by the hand and the pen. If the light comes from the right, the shadow prevents our seeing clearly what we are doing. It is very bad for the eyes to have a strong light directly in front.

It is in altering the form of the lens so as to focus near objects that the eye has most work to do. On this account we should not sit too long at a time doing "near work," such as reading or sewing. The smaller the type or the finer the sewing, the greater is the fatigue caused to the eyes. They begin to feel tired, and almost in spite of ourselves we find our

eyes looking over the top of our book to something more distant, in order to rest for a moment those small muscles that focus the nearer objects.

You know that the curtain or iris shuts out some light by making the pupil smaller when there is strong sunshine or a bright glare from the snow. People who are much out of doors in such light, however, must often wear a kind of spectacles to screen the eyes, and if they do not they may suffer from the painful trouble of snow blindness. Usually we can be out of doors all day without fatigue to the eyes. The green of the trees and the grass is restful, and we are not fatigued with looking too close at things.

We should take account of the needs of the eye in arranging our houses. The colour of the walls should be quiet and restful, like the colours out of doors, and not too dark and dingy. The light should be arranged so as to fall suitably upon the work which we may be doing. All our surroundings should be bright and cheerful, for though we may give no heed to many of the pictures which our eye is constantly receiving, yet these pictures do much to make our general feeling pleasant and agreeable, and thus they actually promote our general health. Grand houses or costly furniture and ornaments are not needed for this. There is no more beautiful room possible than a simple, clean, and comfortable cottage kitchen. A boyhood or girlhood passed in such a home makes one rich in the best kind of memory pictures in after life.

CHAPTER XXII

THE EAR

Some little time ago a lady who had been out shopping found a telegram awaiting her on her return. She picked up the familiar envelope, and unfolded the thin paper with its typewritten message. Her face lighted up with interest as she read the words, "Boat delayed: arrive Thursday." Above this were the heading "Cape Race Wireless" and the name of a steamship, and this was almost as interesting as the message; it was the first wireless message or "Marconigram" that she had ever received, and it stirred her imagination to picture out the whole history of that wonderful telegram.

Her friend was crossing from the Old Country, and would shortly arrive at Quebec; she had indeed made an appointment to meet her in Toronto on Thursday. On the open ocean, however, something had happened which made this impossible. Head winds and seas may have kept the steamer back, or time may have been lost by fog coming on. But now the weather was fair again, and the boat was nearing land; her friend therefore decided to send a wireless message telling when she might be expected.

The lady pictured to herself the ship ploughing through the great ocean waves, or creeping cautiously through a thick bank of fog where icebergs might be

"*Crossing from the Old Country*" (p. 254). *Note the two long wires stretching from mast to mast: they are the "ear" of the ship, and catch the electric waves of wireless telegraphy.*

lying in wait. Then the delay being past she saw the message written out and handed to the wireless operator in his little cabin high up on the topmost deck. She heard the mysterious crackling and snapping sounds which told of electric waves being sent away far over the sea. How strange it seemed that her own name and address and this simple message from her friend should be thus thrown out into space for some other wireless operator to receive, it might be hundreds of miles away! Then she saw the lonely Marconi station perched upon the Newfoundland shore, with its watchful attendant waiting to catch up every electrical impulse which came streaming in upon his receiver. There the series of waves which spell out the message had been caught and interpreted.

But they had not yet reached *her*. The message was now handed to another operator and sent on as an ordinary telegram; the electric signals now travelled along solid wires, in submarine cable or on telegraph poles, until they reached the telegraph office near her home, and were there translated into letters and words. These words conveyed the meaning which had been in her friend's mind, and so by means of this wonderful process a *thought* had travelled from one person to another across hundreds of miles of space.

"It is very wonderful," the lady said to herself; "but what makes it seem so wonderful is the great distance which those electric waves can travel. In other respects it is very like what happens when one hears the words which are spoken by another." This is quite true. To a person who had no knowledge of sound or of hearing, it would seem like a miracle if you could tell him what was going on outside, or who was in the next room, by the use of the ear. We have a somewhat similar feeling

of wonder at being able to send wireless messages to ships and to places far beyond the horizon. When we examine the structure of the ear, we shall find that there are several ways in which its action resembles the receiving of wireless messages.

What we usually call the "ear" is the flap-like structure which projects from the side of the head. This is

"*The wireless operator in his little cabin*" (p. 256). *The Marconi signal-room on board a man-of-war.*

merely a sound-collector, and acts like the ear-trumpet which some old people use. This natural ear-trumpet of the human ear is much less useful than that of some of the lower animals. When your little brother listens very eagerly, you sometimes say he "pricks up his ears," but probably he could not really prick up his ears if he

tried. Some people can move their ears a little, however; there are muscles under the skin which were once used for this purpose, no doubt, but they have become small and feeble through lack of use. We do not need to listen so keenly to every sound as our savage forefathers did; our enemies are not always on the prowl to fall upon us unheard. If you watch the ears of a dog or of a horse, however, you will see how their ear-trumpet moves so as to meet and gather up the sounds, and to let the animal know from what direction they are coming.

But what do we mean by collecting *sounds?* What is it that the ear-trumpet really gathers up? A sound is produced by the rapid vibration or to-and-fro movement of some sounding body; this vibration sets the air in motion in a similar way, each movement of the body sending out a wave through the air, just as you see a ripple sent out from the place where you drop a stone into a smooth pool. The stone makes the water move up and down in a wave motion; the particles of air move backwards and forwards in forming the waves which produce sound.

When a bell rings, the clapper strikes the side of the bell and makes it vibrate or shake. The strings of a violin vibrate when the bow is drawn across them. The human voice is produced by the vibrating of the vocal cords as the breath is forced through between them. All those movements set up waves in the air by which the sound is carried in every direction. The Marconi or other wireless telegraph instrument also sends out waves; these are electric waves, and travel much more quickly than the sound-waves travel through the air. In both cases, however, it is the *waves* which convey signals to a distance, and so both are wireless messages.

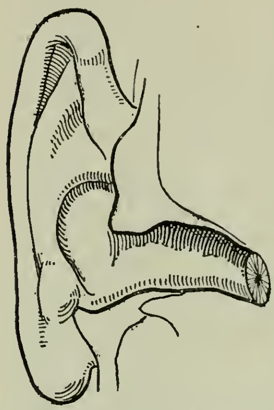
The sound waves or vibrations in the air are collected by the outer ear, and are thus passed on into the canal or tube which runs inwards from it. In the skin which lines this canal there are cells which produce a substance called wax. The wax of the ear acts as a protection, as

"*The lonely Marconi station perched upon the Newfoundland shore*" (p. 256).
Cape Race Lighthouse and Marconi tower.

it entangles any small insects which may get into the canal of the ear. The small, stiff hairs which grow at its outer end are useful in the same way.

The inner end of this canal is closed by a membrane which is tightly stretched across it. This membrane is called the *drum* of the ear. As the sound waves strike against it they make it vibrate or swing to and fro, just as the body did which produced the sound waves. The

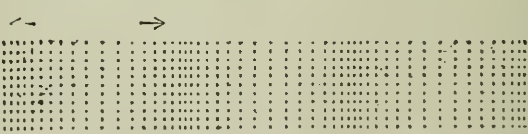
progress of the waves up to this point has been like that of the electric waves of the wireless telegraph. When your mother speaks to you across the room, sound waves are sent out by her voice which are caught up by your outer ear and passed on to the drum, just as the electric waves were sent out by the telegraph operator on the ship and received by the operator at Cape Race.



The outer ear with the canal in section, showing the drum.

That operator, as we have seen, sent on the message to its destination by means of a wire or cable. Our ear does something very similar. From the drum the vibrations pass to the brain through an arrangement which acts the part of a telegraph wire. The instrument used by the telegraph operator would seem to us very hard to understand. The receiving and transmitting parts of the ear are also somewhat complicated, but we must try to understand their working.

The receiving part, as we have said, is the drum. Its



"*The particles of air move backwards and forwards in forming the waves which produce sound*" (p. 257).

proper vibration depends upon its being tightly stretched, and being free to move under the impulse of each sound wave. On this account it must have the same pressure

of air on the inside as on the outside. The chamber which lies on the inner side of the drum has, therefore, free communication with the air by means of a tube which passes to the upper part of the throat. Sometimes, when we have a cold or a swollen throat, there is an unpleasant feeling in our ear, and we do not hear well. That is because this tube is closed up by the swelling, and the air cannot pass freely to the chamber of the ear which lies beyond the drum. When this happens, the drum does not vibrate freely to the sound waves.

The bony box or chamber of which we have spoken, and which lies beyond the drum, is called the *middle ear*. Stretching across the middle ear, from the drum inwards, is a chain of three bones. On account of their shape, these bones have been called by Latin names which mean the *hammer*, the *anvil*, and the *stirrup*. The hammer bone is attached to the drum, and when the drum vibrates the hammer vibrates too. Thus the vibrations pass along the chain of bones to the inner ear.

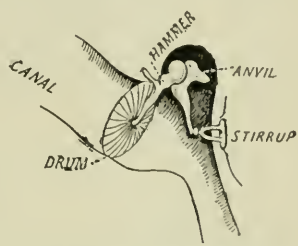


Diagram of the middle ear. Note on the left the canal of the outer ear, and on the right the tube which leads downwards to the throat.

The *inner ear* is a bony chamber which is filled by a watery fluid, and the stirrup bone fits into its wall and transmits the sound vibrations to this fluid. We can scarcely describe the inner ear as a box, as in the case of the middle ear; it is rather a maze of canals filled with fluid. The chief part of the maze is shaped like the shell of a snail, and on account of its spiral shape is named the *cochlea*, a Latin word which means a snail.

In this is a platform or partition with a large number of cells, and among these are the endings of the nerves of sound or hearing, which are the central receivers of the sound vibrations.

You see, then, what an elaborate instrument the human ear is. The sound waves give rise to movements of the drum, and these produce movements of the chain of bones in the middle ear; in the inner ear these movements are carried by the fluid to the endings of the nerves, which then convey the sensations to the brain. These nerves carry messages of sound. Like the nerves of sight, they convey messages of one kind only. By means of these nerves, then, the message reaches the brain. Outside the ear it is transmitted by "wireless;" from the drum of the ear inwards it is carried by a special telegraph line built up of bone, fluid, and nerve.

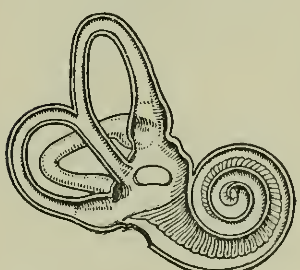
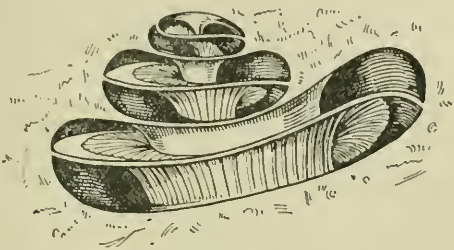


Diagram of the inner ear: on the right the cochlea, laid open; and on the left the semicircular canals, the two nearer also laid open.

A diagram of the inner ear shows some parts which we have not yet mentioned. Near the spiral chamber there are three semicircular canals, which are also filled with fluid. These canals do not seem to have anything to do with hearing. Not very long ago, however, it was found out that they have a special duty of their own. They are concerned with the balancing of the body. It is by means of messages sent from the nerves of these canals to the brain that we can tell the position in which our head is placed—whether upright or lying down.

This complex and delicate organ may be easily

injured, and it is generally impossible to repair any injury it may receive. How can we avoid hurt to the ear? In the first place, we can prevent anything getting into the canal of the outer ear. Children sometimes push things into their ears, such as beads or the end of a pencil. This may injure the thin and tightly stretched



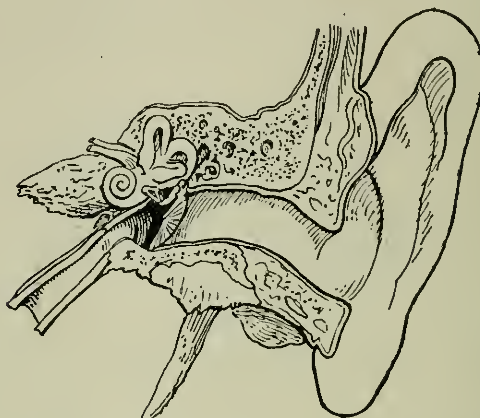
Vertical section through the cochlea. Note the partition or platform with the cells and nerve endings.

membrane of the drum, and if the drum is destroyed the hearing is lost.

We must never, even in play, strike any one on the ear. A slight blow is sometimes enough to damage the delicate structures within. We must remember that disease in the throat may cause injury to the ear; a common cause of deafness is a swollen condition of the throat which prevents free entrance of the air into the middle ear. Sometimes wax collects and hardens in the outer ear and blocks up the canal, preventing the free passage of the waves of sound. When this happens, the wax must be very carefully removed by syringing with warm water, and not by any use of force.

Can we hear or not hear, according as we wish? We cannot shut our ears to sound as we can shut our eyes to light, but we can *listen* or *not listen* to the sounds and voices that fall upon our ears, and that comes to

much the same thing. More than that, hearing is an art which does not come by nature, but must be learned and practised. If we look at a class in school or a grown-up audience at a lecture, we shall see that many



Section of ear, showing the general arrangement of parts.

individuals are not following attentively what is being spoken. Probably they *mean* to listen, but they have not learned *how* to listen. That requires the habit of attention. We can only listen to one thing at a time, however many sounds may be falling upon our ears, and we ought to form the habit of keeping on listening to the one thing which we select, and not allowing the attention to wander aimlessly among the crowd of other sounds and sights which are trying to force themselves upon our notice. To listen well means that we can "turn a deaf ear" to the things which would distract us.

CHAPTER XXIII

TOUCH, TASTE, AND SMELL

HAVE you ever thought what the world must be like to those who are blind? They live in what we call darkness, but darkness is not the same to them as it is to us. Darkness is the absence of light, but they cannot feel the *absence* of light if they do not know anything about light. Their world has none of the sensations which come from light or colour. It is not by their faces that they recognize their friends, but they recognize them quickly by other signs which you would never notice. We trust so much to our eyes that we often neglect the messages which come from our other senses.

Blind people are usually very cheerful and happy. One gate of the mind is closed, but they make the most of the sensations which enter by the other gates. In schools for the blind, the children learn as many lessons as you do—perhaps more. They read and write and count, and learn geography and other subjects just as you do. Of course they learn in a different way. All their knowledge must come by the gateway of the ear, or by that of touch, or by taste and smell. What seems most wonderful about the learning of these children is the way in which they use the sense of touch to make up for the want of sight.

If we listen to a blind boy reading, there is nothing to tell us that he is not looking at the page of his book just as we do ourselves. Let us watch him and see how he does it. We notice that he runs his fingers along the line before he begins to read, just as we glance at the words that are coming before we actually say them. The book, however, is quite different from our books. The letters are not formed in black ink upon white paper; they are raised or embossed so that they can be felt with the fingers. They are differently shaped in most cases, too, and have a simpler form.

When the blind boy learns a letter, he moves his fingers along its outline, and the messages of touch and of finger movement are sent to the brain, and so its form is known and remembered; next time the letter is met with, the touch of the finger calls up the memory of what had been learned. You learned these things by the sense of sight. Your eye moved along the outline of the new letter, and messages of light and of eye movement were sent to the brain. The chief difference is that for the blind the messages of touch must take the place of the messages of light. You may have heard it said that blind people have a keener sense of hearing and touch and smell than other people. That is not the case, but they have learned to *attend* more closely to the messages of these senses. A blind person can tell a great deal about a thing from merely touching it.

It is marvellous, indeed, how much can be learned by means of the sense of touch. Laura Bridgman was a New Hampshire girl who at the age of two years had a severe illness and lost the sense of hearing, taste, and smell, as well as the power of speech. She also became almost blind, being only able to see a little

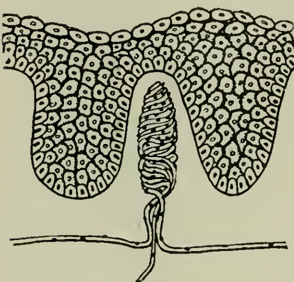
with one eye, and at the age of eight even this power was lost. The sense of touch alone remained to convey messages to her mind from the world without. Her education had to be carried on through the tips of her fingers. She learned the names of things by the use of raised letters. By means of her fingers also she learned to write and to speak. She learned arithmetic, and we are told that after nineteen days she could add a column of figures amounting to thirty. She also studied algebra, and geography and history. She kept a journal, and wrote poems. She learned needlework and other domestic employments.

Helen Keller of Alabama also lost through illness the senses of sight, hearing, taste, and smell, the sense of touch being the only gateway of knowledge left to her. Not only did this girl learn all the subjects usually taught at school, but she was a very successful student at college. She studied English, French, German, Latin, and Greek, and has written several interesting books, in one of which she tells the story of her own life, with its brave struggle against her dreadful difficulties.

All the senses are alike in this, that through them messages are passed in to the brain. In each case there is a nerve ending which receives a special kind of stimulus or message, and a nerve which conveys this message to the brain cells. The difference between one sense and another lies in the kind of nerve endings which it employs and the kind of message which these receive. Thus the eye is merely a collection of special cells which receive messages of sight, and the ear is a collection of cells which receive messages of hearing. Light falls upon the whole body, but only the nerve endings in the retina are affected by it; sound-waves

strike against the whole body, but only the nerve endings in the ear receive the sensation of sound from them.

The nerve endings which receive sensations of touch are not confined to one part of the body, as with the other senses. It seems to us as if it were by means of the skin that we receive these messages, but the whole of the skin is not sensitive to touch. When a portion of the skin is examined under the microscope, there are seen certain small oval bodies which are the nerve endings of the nerves of touch. They are called *touch corpuscles.* When the skin comes in contact with any object, these small corpuscles are pressed upon, and they send messages along their nerves to the brain. So by the pressure on these bodies we can tell whether the thing we touch is rough or smooth, hard or soft, sharp or blunt. We can also tell what part of our body the messages are coming from.



Section of outer skin showing a touch corpuscle.

All parts of the skin are not equally well supplied with nerves of touch, and so the acuteness of the sense differs greatly in different parts of the body. The sense is much more acute, for example, in the tips of the fingers than on the back of the neck. If you touch the finger tip of a friend with two pencils, while he keeps his eyes shut, he can always tell that there are two points, however close you may hold them together. If you touch him in the same way on the back of the neck, he will not be able to feel that there

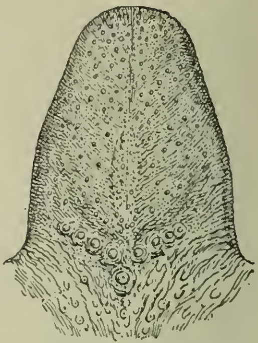
are two points unless you hold them nearly an inch apart. You have always known that your fingers and hands are the best parts to feel any object with, but perhaps you did not know the reason before.

There are certain other nerve messages which come to the brain from the skin. They are not messages of touch, strictly speaking, but they tell us certain facts about our surroundings or about the body itself. *Pain* is one of those messages. It is a message of discomfort either from the surface or from the internal parts of the body. Other messages are those of *heat* and *cold*, which are sent in from the skin. We usually think of cold as being merely the want of heat, but to the skin a feeling of cold is quite a distinct thing. There are certain parts of the skin which send in messages of heat, and other parts which send in messages of cold. The sense of heat and cold is very unequally distributed over the body, just as we saw the sense of touch to be. If you have ever watched a nurse making a poultice, you may have noticed that she holds it to her cheek to test its heat. A laundry-maid will also hold her smoothing-iron near her face to judge whether it is hot enough.

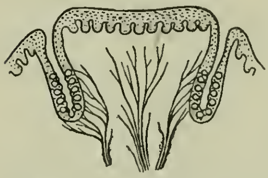
There are also nerve messages constantly passing to the brain from the muscles and the joints. These messages tell of the position and the movements of parts of the body. Shut your eyes, and get a friend to put your arm into any position; you will find that, even with your eyes shut, you can tell exactly how your arm is placed. You can say, "My right arm is bent up at the elbow," or "My hand has been closed," just as surely as if you were watching with your eyes. The nerves which carry these messages are distinct

from the nerves of touch, and we speak of the messages which they bring as the *muscle sense.*

The sense of *taste* is located in the mouth, especially in the tongue. The tongue is covered on its upper surface with small projections, and at the back part there are larger projections or *papillæ,* which have a sunk ring or trench round them. On the sides of these papillæ are the receivers or nerve endings of the nerves of taste. They are formed of groups of special cells arranged in the form of a bud, and are known as *taste bulbs.* Besides being found on the sides of the papillæ, taste bulbs are found on the palate and on the epiglottis—the lid-like structure which shuts over the larynx.



The tongue. Note the papillæ near the back part.



Section of a papilla, with taste bulbs in the sunk ring.

The thing tasted is dissolved by the fluids of the mouth, and thus comes in contact with the taste bulbs. There are really four different kinds of taste messages which these bulbs send to the brain—the tastes which we call *sweet, sour, salt,* and *bitter.* In addition, we can detect a large number of different flavours in our food and drink—different kinds of sweetness or sourness, and the like—and we imagine that these flavours are also perceived by the sense of taste.

Section of a taste bulb.

This is a mistake, however. Flavour is detected by the sense of *smell*.

When we have a bad cold which interferes with our sense of smell, we usually find that nothing we eat has its proper taste. It is not the sense of taste, however, but smell which the cold has put out of order. Sometimes we confuse taste with touch, for there are nerve endings of touch in the mouth too. When we speak of something having a "gritty" taste we do not really mean that we taste its roughness. We distinguish roughness or grittiness by touch.

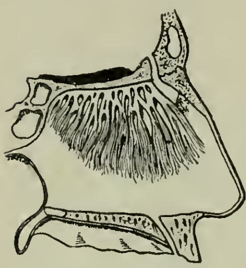
You can find out by simple experiments how much of what you call taste is really smell. Hold your nose tight so that no breath passes through it, and you have no sense of smell. Put into your mouth first a bit of orange, then of apple, and then of turnip. You can feel the orange different from the others because it is soft and pulpy. The apple and the turnip, however, are so much alike that you cannot distinguish between them until you release your nostrils, and then you perceive at once the difference of flavour. It is impossible even to recognize a bit of onion by the taste alone while the nose is thus compressed.

Although we receive from the sense of smell a great deal of what we usually call taste, yet the sense of taste itself is very acute with respect to the qualities which belong to its sphere. It can detect a very slight degree of bitterness, for example. There is a very bitter poisonous drug called strychnine; we can detect the bitter taste of this substance even when it is diluted with two million times its own bulk of water.

The sense of taste is of some use as a guide in choosing food, but it is by no means a sufficient guide as to what is beneficial and what is harmful to the

body. It sometimes happens, for example, that food changes so much with keeping that it becomes highly poisonous, and yet this change cannot be detected by taste.

The nerves of smell have their special nerve endings in the nose. The upper part of the cavities of the nose are lined with a thick membrane in which are cells with hair-like outgrowths. It is in connection with these cells that we find the nerve endings of the nerves of smell. The smell of any odorous substance is due to minute particles of vapour which pass from it into the air. These particles strike against the nerve endings in the nose and excite them, giving rise to the sensation of smell. Some smells are extremely persistent; a very small quantity of musk, for instance, will retain its odour for years.



Section of nose, showing nerves of smell.

We do not make much use of the sense of smell, and in man it is very poorly developed as compared with many animals. Where beasts of prey are found, it is the sense of smell which they chiefly use in tracking their prey, while the hunted animal often trusts for safety to the keenness of its scent in giving warning of the enemy.

Tracking their prey by the sense of smell (p. 272). *The favourite English sport of fox-hunting.*

CHAPTER XXIV

EXERCISE

THE ancient Greeks worshipped many gods. The names of some of them, either in the Greek or the Latin form, are familiar to us to-day, such as Jove or Jupiter, Apollo, Mercury, and Venus. Many of their gods were a kind of poetical personification of natural objects or powers; Jupiter with his thunderbolts was the god of the sky, Apollo the sun-god, and so on. Among their gods was one Æsculapius, who was worshipped as the god of health and healing. Some said that Æsculapius was the son of Apollo, the sun-god; this was their poetical way of saying that good health depends much upon sunshine. We put the same truth in a more scientific way when we say that sunshine kills the germs of disease.

Hygieia, the goddess of health.

Æsculapius, according to the old Greek myth, had four daughters whose names meant "Health," "Brightness," "Recovery," and "Cure-all." After a time the goddess "Health," or *Hygieia*, as her name was in

Greek, came to be worshipped in the temples that were erected to her father Æsculapius. In works of art she is represented as a maiden wearing a long, flowing robe. Her face has an expression of mildness and kindness. She is usually represented as feeding a serpent out of a cup. The serpent was the symbol of wisdom and the art of healing.

The name of this ancient goddess is not yet forgotten among us, for our word "Hygiene" is derived from that name. By hygiene we mean the art and practice of being well and keeping well, or, more simply, the knowledge of the laws of health. But Hygieia was not only the goddess of the health of the body; she was also the goddess of health of the mind. So to understand rightly the meaning of hygiene we must think of it as having to do with healthy minds as well as robust bodies.

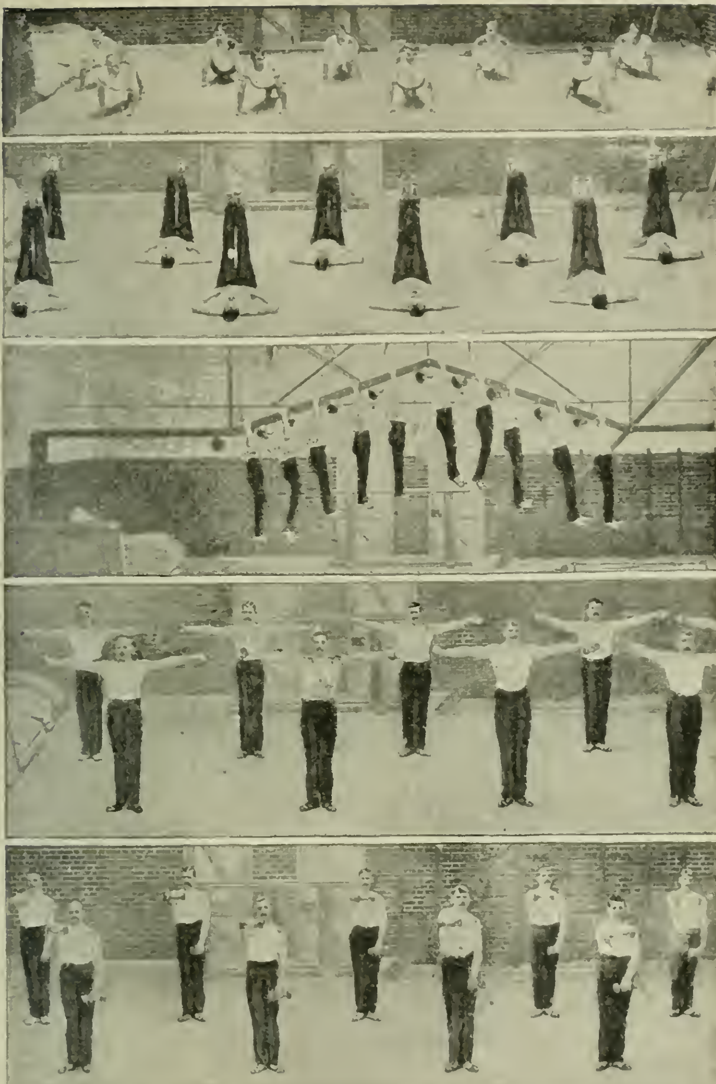
Up to the present, we have been engaged chiefly in studying how our bodies are constructed and how the various parts do their work. We have learned something about digestion, and how the food performs its part in keeping us well and strong. We have learned how the blood flows through the body and nourishes it. We know how breathing is carried on, and how it removes waste matter from the body. But all these things are done by the body itself. Perhaps you have felt that after all we cannot do very much to help the work of breathing or to assist the flow of the blood. As to digestion, we can indeed do something in the choosing and the preparation of food, but we have very little power over the actual process of digestion. For the rest, it has seemed as if all we can do for the body is to avoid injuring it or interfering with its natural working.

We have now to consider some aspects of the body which will show that we can do a great deal to help its proper action and so to promote health. When we do the things which are known to be helpful to the body we obey the laws of health or hygiene. And the observing of these laws will produce effects on the body which may have seemed quite beyond our power—the improvement of the circulation and the digestion, and the promotion of a greater alertness and activity of the brain.

A most important thing to consider in living a healthy life is how to use our *muscles* wisely. You may wonder why our muscles are so important, and why we are so often told about the exercise of the muscles. It does not seem to you, perhaps, that they have really much to do with our health; the internal organs of the body, you would say, have much more to do with keeping us in health than the muscles. Let us look into this matter a little more carefully.

In the first place, our muscles form the largest part of our body. More than one-third of the tissues of the body is muscle. If this mass of tissue is not kept in proper condition, by means of exercise in doing the work which it was intended to do, the body cannot be in a healthy state.

In the second place, it is in the tissues of the muscles that by far the greatest part of the fuel contained in our food is burned up. In our bodily engine, therefore, the action of the muscles is very important, for upon their action depends chiefly the production of heat in the body. Probably it has never occurred to you that the muscles are the main source of our heat supply. Yet you have been acting all your life as if you knew this. When you feel cold



Soldiers practising gymnastic exercises.

you move about, you swing your arms and stamp your feet. That is to say, when you need more heat you set some of your muscles in action, so that they may produce heat.

There is a third reason why the muscles are important in the preservation of health. The muscular part of the body is the part over which we can exercise most direct control. The skeletal muscles—that is, those which are attached to the bony framework of the body—are under the control of the will. We send messages to these muscles by means of the nerves. The stimulus to action carried by the nerve causes the muscle to contract, and it does this by its fibres becoming shorter and thicker. When a muscle contracts, a very complex chemical change takes place in it. This change results in the production of heat and the formation of waste matter. The food fuel is burned up, and energy is produced; part of the energy takes the form of work done in the contracting of the muscle, and part is given out in the form of heat.

When much muscular work is done, much heat is produced and a large quantity of waste matter has to be carried off by the blood. At the same time the pressure caused by the contracting and relaxing of the muscle fibres helps on the flow of blood in the veins. When this is going on all through our muscles you can see that it must have a great effect upon the body. Let us see what are some of the special results of muscular exercise upon different parts of the body, in order that we may understand what rules we should observe in taking such exercise.

Exercise has an important effect upon the *lungs*. It increases the quantity of air taken in and given out. The quantity of air breathed when one is swimming

is about four and a half times as much as is used when one is lying still. At the same time the flow of blood through the lungs is much increased. From this we can see the reason for one important rule regarding exercise; we must have abundance of fresh air when we use our muscles vigorously, and, therefore, exercise is best taken in the open air. A second rule is seen

Outdoor games—Baseball at the "Forest School," Toronto.

to be equally necessary; our lungs must be free to act. We must not hamper them with the pressure of heavy or tight clothing on the chest.

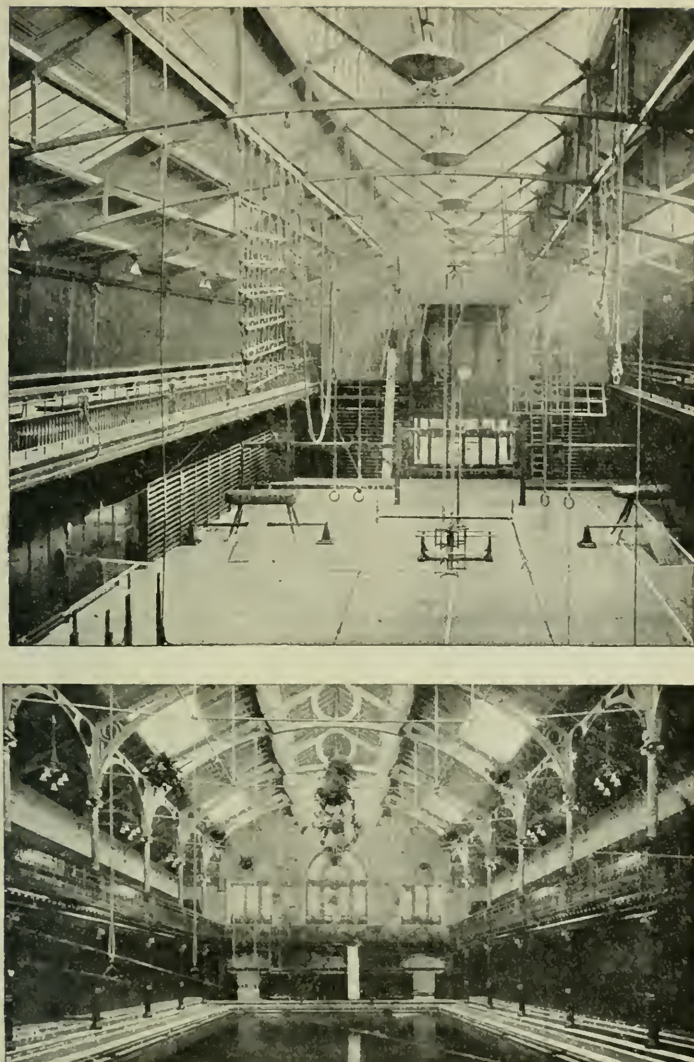
Let us next see how muscular exercise affects the *circulation of the blood*, in order that we may discover from that whether there are special rules to be observed. Exercise increases the rapidity of the heart's action, and hurries the circulation generally. You can easily test this for yourselves. While sitting quiet, count the

beats of your pulse and see how many there are to the minute. Then jump as high as you can, ten or a dozen times. Now count the rate of your pulse again. You will find that the exertion of jumping has made it much quicker.

You will remember that the heart gets its only rest in the short pauses between its beats. When the pulse is quickened, its time of rest is shortened, and this resting time must not be too much interfered with. An obvious rule, therefore, is that exercise must not be continued so long as to over-tire the heart. If we increase the time given to any exercise by degrees, day after day, the heart will gradually get accustomed to it, and there is less risk of injury. Many men who were splendid athletes for a time when they were young have a heart seriously damaged by unwise or excessive practice of athletic exercises. They were so keen to excel that they did not give their heart time to get accustomed to the increased work. The result is a weakened heart, and less strength and health in middle life than they would have enjoyed if they had taken exercise more wisely. Whenever any exercise is continued until it causes breathlessness, the heart is being over-taxed.

The *digestion* is also much affected by muscular exercise. The more the work of the muscles is increased, the more fuel is consumed, and a larger amount of food becomes necessary. At the same time the digestion is improved, so that a larger quantity of food can be digested. When little exercise is taken, the body will not digest so much food, and we should therefore eat less than when we are engaged in active exercises.

The effect of exercise on the *skin* is easily seen. It



A modern gymnasium and swimming bath,
Dunfermline College of Physical Training, Scotland.

causes the skin to become flushed with blood, and perspiration is increased. This perspiration is a means by which the body gets rid of the excess of heat which exercise produces. From this we see the importance of keeping the skin clean and in an active condition. We also see that only light clothing should be worn during exercise, and that when the exercise is over some additional woollen garment should be put on to prevent the too rapid cooling of the skin.

The *muscles* themselves are affected by exercise. They grow by use. The muscles which are much used actually increase in bulk, although the person may have stopped growing otherwise. It is a mistake, however, to think that there is any advantage in having a few of the muscles of great bulk. It is much better to have all the muscles of the body moderately exercised than to have the muscles of the arm, for example, enormously developed while those of the back are hardly used.

The effect of exercise upon the *brain* and the mind depends upon the amount taken. Violent muscular exercise tires the brain. We may see this in the case of a mountaineer who has done great feats in climbing some lofty peak. He may find when he reaches the top that he cannot remember any of the details of his climb. His muscles were so violently exercised that his mind was no longer clear. Moderate exercise, however, improves the working power of the brain. The want of exercise interferes with the general health, and so makes the brain less able to do its work.

Exercise is much more necessary for the maintenance of health at the present day than it was long ago. If we go back a century or two we find that people lived under conditions very different from those under which

most of us live to-day. Their houses, their food, and their dress were different, but the most important difference was in their manner of working. They used their muscles much more than we do. All the work on the farms, such as sowing and harvesting, was done by hand. Spinning and weaving and all manner of work in wood was also done by the power of the

" *Exercise is best taken in the open air* " (p. 279). *Indian Club exercise.*

muscles. If we go still farther back to the time when men lived by hunting, and when tribes were usually at war with one another, we see that the support of life and the defence of life depended upon the strength of men's muscles.

In our day things are very different. Machinery has taken the place of hand labour in hundreds of ways. People live more largely in towns, where street cars make walking almost unnecessary. The manufacture

of all kinds of things is carried on by the power of engines of various sorts. Even on farms, where there must always be a large amount of manual work, the labour is lightened by the use of machinery. Life has become more comfortable, and in many ways more favourable to health. But we use our muscles less, and that is a danger. Good health cannot be preserved without the regular active use of the muscles. Not only do the muscles themselves become weak, but the whole body suffers, including the brain and the mind. Hence the importance which we now attach to such forms of exercise as will keep the muscles and the whole body healthy.

People have tried to find out what amount of muscular exercise a man needs every day in order to keep well. One calculation that has been made shows that a man should do as much daily muscular work as would be equal to a walk of nine miles. Labourers often do three times this amount of work in a day. The best form of exercise for children is free play in the open air. How much of this is required? The best plan is to leave the amount to the body itself to judge. The body takes care of itself if we allow it to do so in a natural way. When it needs food, we are warned by the feeling of hunger. When it needs sleep, we feel sleepy. So when the muscles have had enough exercise, we feel tired.

The feeling of tiredness or fatigue is caused by the waste products accumulating in the muscles. More waste matter is produced than the blood can carry away. For the time the body is being poisoned by these substances. When we rest we allow time for the blood to carry away these waste products from the muscle.

People sometimes speak of brain fatigue as if that were something different from muscular fatigue. An Italian professor who has made many experiments in this matter has shown that the two kinds of fatigue are alike. He measured the degree of fatigue by the number of times a person could lift a certain weight by bending the middle finger. By this means he discovered that brain fatigue made one less able to go on raising the weight, just as fatigue of the muscles did. Fatigue changes for the time even the appearance of the nerve cells. The nerve cells of a bee just about to set out from the hive in the morning are quite different in appearance from those of a bee which has been on the wing all day. For the complete recovery from fatigue sleep provides the rest that is needed.

We must now consider some of the kinds of exercise which we may take in order to promote health. Outdoor games are a most valuable kind of exercise. This is partly because they are so interesting that those who play do so with vigour and are eager to do their best. But in addition to the healthful exercise which they afford, games also provide a valuable training for the mind. They teach us to play fair, and to take a beating cheerfully, which are useful lessons for all our life. Games played in teams, such as football or hockey, also teach us to play for our side, and not for our own advantage or to win renown for ourselves. A member of a team may be a very brilliant player, but if he plays a selfish game he is of little use to the team, and has not learned the best lesson of the game.

While young people are right in their preference for games, there are times when games are not available;

"Outdoor games are a most valuable kind of exercise" (p. 285). *Rugby Football.*

besides, strenuous games are not advisable for all. Indeed, no one should undertake any violent form of exercise without having been examined by a doctor. Most good schools employ a doctor for this purpose, and medical examination is becoming a regular part of the school system. Other forms of exercise can then be found which have advantages of their own. The best of these is walking. Walking is always possible; it requires no apparatus and it costs nothing. It is suitable for persons of all ages, and can be enjoyed either alone or in company with others. The chief benefit of some of our more expensive forms of exercise, such as golf, is simply the amount of walking which they require. The benefit to health which some men receive from a hunting or shooting holiday is due very largely to the same cause. They must live in the open air, and they must walk a great deal. Walking exercises the muscles of the leg chiefly, but many other muscles as well, for the balance and support of the body in the erect position calls a large number of muscles into play.

Running is a more violent form of exercise than walking. It consists of advancing by a series of leaps, off each foot alternately. Running is a most important element in many outdoor games, and is enjoyed by young children merely for its own sake. With older boys running often takes the form of tests of speed on a racing track, or of speed and endurance combined, in the form of paper-chases and cross-country runs. Running is suitable only for those who are in good health. The heart is easily over-taxed with so severe an exercise, and it is the heart rather than the legs that is apt to suffer from fatigue.

Swimming is a form of exercise that is easily learned

by children. It is not only a delightful kind of exercise in itself, but it is often very useful as a means of saving life. It is a pity that all children do not learn to swim. No one who has the chance of doing so ought to neglect it. In swimming, more use is made of the muscles of the arms and shoulders than of those of the legs, and for this reason it forms a valuable change from walking and running. Swimming is of great use in developing the power of breathing. It also strengthens the muscles of the back, and so helps to give one an erect bearing.

Cycling is a good exercise for the muscles. One advantage of cycling is that it must be carried on in the open air. On this account cycling has done more for the health of people who live in cities than any other invention of modern times. But at the same time there is the risk of over-strain, and much harm has been done by the unwise use of the bicycle, especially on the race track, and by young boys and girls overtaxing their strength. Moreover, the bicycle should be carefully adjusted to suit the rider, or a curved back is likely to result. When wisely used, cycling combines a pleasant and healthful outing with a considerable amount of muscular exercise. It does not develop the chest and the breathing power as swimming does, but it takes many people out into the country roads who would otherwise stay indoors, or would merely walk along a city street.

Gymnastics was the name given by the Greeks to all forms of organized bodily exercise. We use the word to include such outside sports as those already referred to, as well as the drill and athletics which are usually given indoors in schools and gymnasiums. The course of physical exercises which has been adopted for schools

in all the provinces of the Dominion of Canada is based upon the Swedish system. This system, known also by the name of its inventor, Ling, has been introduced into many other countries. It is the result of very careful scientific study of the movements of the body. The exercises are planned so as to call into use all the muscles of the body and develop them all alike. At the same time they train the nervous system in the control of the muscles, so that the body may be kept in the best condition. This sort of exercise is not simply play; it is a form of work, though a very healthy form. It is advisable, therefore, that every gymnastic lesson should include some form of play, such as a game or a dance, in order to make the best use of the change from ordinary school work.

Dancing is one of the most delightful as well as one of the best forms of exercise. It exercises chiefly the leg muscles, but many others are brought into action as well. The essential thing in dancing is graceful movement, and this depends not merely upon the leg movements, but also upon the erect carriage and balance of the body, the head, and the arms, and the smoothness and precision of all the muscular action. Dancing forms an excellent substitute for some of the less interesting school exercises. In the village festivals which were formerly common in England and other countries of the Old World, a favourite amusement was dancing in the open air, which is the most beneficial form of dancing. In many European countries this amusement is still practised. Some people are trying to bring back this simple, old-fashioned habit, and children are being taught in many schools the old games and dances of former days.

Gymnastics also includes exercises done with special apparatus; indeed the word is often used for such

exercises alone. The apparatus may either be hand apparatus, such as wands, dumb-bells, and clubs, or fixed apparatus, as rings, ropes, and bars, and they may vary in size. These exercises usually put considerable strain on the muscles, and are very useful for grown-up persons if they are performed under careful supervision. Only the lighter kinds are ever advisable for children.

Athletic exercises often take the form of preparation for contests, such as races of various kinds. For such strenuous muscular feats it is usual to have a period of "training." This means not only practising the exercises, but also giving special care to diet and the general manner of living, so that the body may be in the best condition to stand the severe strain. A man in "training" must eat simple food, avoiding such articles of diet as are apt to produce fat. He must drink only moderate quantities of water, and must not touch alcohol or tobacco. He must exercise regularly, and gradually increase the amount of exercise taken each day. He must keep regular hours, and have plenty of sleep. These rules, you will notice, are merely the ordinary rules of health which people observe every day in a greater or less degree; but they are very rigidly attended to, while the amount of exercise taken may put a severe strain upon the body in various ways. Only very strong, healthy boys should be allowed to "train" for athletic contests of any kind. All the exercise which health requires can be taken without the risks which the athlete is willing to run for the sake of winning some "event." In many cases, as we have already said, the result of such contests is a weak heart and impaired health in after life.

CHAPTER XXV

CLOTHING

Travellers tell us that in warm countries the uncivilized native races revel in bright colours. They will exchange whatever they possess—ivory or rubber or anything else—for a few gaily-coloured beads or some brightly-dyed cotton cloth. They string the beads and hang them round their neck, or they wrap the gay cloth round their body, and feel that they have made a splendid bargain.

According to the learned men who have studied the origins of our own habits and customs, it was in this way that men first began to wear clothes. At first clothing was worn merely as a decoration. As the races of men spread over the world and came to inhabit colder countries, they found that clothing could serve other purposes than that of ornament; it was useful also as a protection against cold.

We have already seen that the wearing of clothes is one of the things that enable man to adapt himself to great variations of temperature. This has made it possible for him to live in almost any part of the globe. Animals have in some degree the power of adaptation to temperature. Where there is a marked difference between the seasons, they often develop a thick winter covering of fur which is much warmer

than their summer coat. Animals whose mode of life demands special protection, such as the seal, have acquired a covering suitable to their needs. The animals of hot climates are much more thinly clad.

It is as a protection against cold that clothes are chiefly worn at the present day, but we still give a great deal of attention to the decorative effect of our dress. It is from this point of view that "fashion" in clothing has arisen and has become so important. In all communities people dress more or less like one another. In Eastern lands, for example, loose, flowing robes or gowns are commonly worn. Among the more active peoples of Europe and of the New World, both men and women wear more close-fitting garments.

But even among the people of the same country there are differences of style, originally corresponding to differences of social position or of occupation among the inhabitants. And in addition to these differences there have arisen other changes of style due to a desire for decorative effect, or to changing taste, or to the simple craving for something new. It is these periodic changes which we usually speak of as "fashion." Dress sleeves, for example, are made wide at one time and narrow at another, without any regard to convenience or comfort, and every one aims at wearing what is the latest fashion. If we see a person dressed in a style which was fashionable only a few years ago, we think it quaint or peculiar—"old-fashioned," as we usually call it. We may have forgotten that our ancestors began to wear clothes simply for the decorative effect, but when we judge clothes by "fashion" we are looking at them very much as those old-world people did. We may smile at the delight of a South Sea Islander over his glass beads, but he is no more

foolish in his desire for ornament than we are in many of our own tastes regarding dress and other personal decorations.

It is very silly, of course, to give too much thought and time and money to mere adornment, but it is neither wise nor beneficial to neglect our personal appearance. When we are well and suitably dressed we have an increased feeling of well-being and self-respect as well as of comfort, and such a feeling of pleasure has undoubtedly a beneficial effect both on body and mind. In this way the gratification of a reasonable taste even in matters of mere "fashion" has a certain value from the point of view of health. But we must make sure that it is "reasonable," for fashion has usually little regard for health, and may easily lead us into serious mistakes.

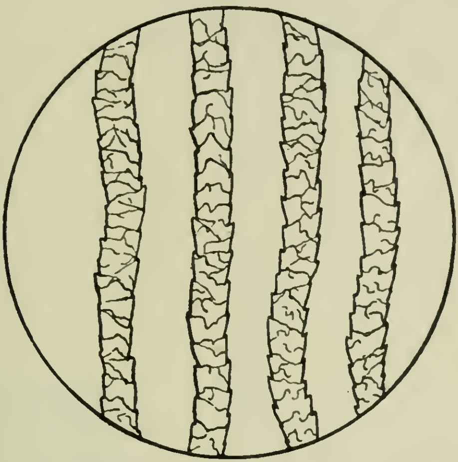
There is another use for clothing which you may not have thought much about. In all countries people are accustomed to show certain feelings or states of mind by the clothes they wear. Sorrow, for example, is indicated among us by the wearing of black; and although in other lands other colours are worn to indicate mourning, it is a very widespread custom to show grief by some special kind of dress. We like to wear white or bright colours on occasions of rejoicing. So we may say that our clothes are used as a means of expression as well as of adornment. Then special styles of clothing are worn to indicate special office, as is done by clergymen in most churches, or special robes are used for ceremonial purposes, as by judges and governors or other officials. It would take many books to contain all that might be written about clothing from such points of view as these. But our chief concern here is with clothing considered as a protection to the body.

Clothes protect the body in several different ways. In the first place, they prevent the loss of heat from its surface. We sometimes speak of " warm clothing." We do not really mean that a fur coat can give us heat. We have already learned that heat is produced within the body by the carbon of our food uniting with oxygen from the air. All that "warm clothing" can do is to prevent this heat from passing too quickly away from the body when the air around it is very cold.

Another way in which clothes protect the body is by keeping dust and dirt from settling on the skin. If we are out-of-doors for an afternoon in any large city and do not wear gloves, we find when we wash our hands that a large amount of dust and grime has gathered upon them. We know that light-coloured clothing soon becomes soiled, but we are apt to forget that dark clothes catch just as much dust as light ones, although we do not see it. From such examples we see how much dust of various kinds there is floating in the air around us, and lying on everything we touch, and our clothing serves to protect the skin from being soiled by this dust.

Again, in very hot countries we need the protection of clothes to shield us from the direct rays of the sun. White men living in the tropics usually protect the head from the fierce sunshine by wearing pith helmets, and the neck and spine must also be shielded from the intense heat. A fourth kind of protection given by clothing is the protection from actual injury to the skin by coming in contact with hard or sharp objects. This is specially necessary for the feet. In many places country children like to run barefoot in summer, but in our cities the hard surface of the streets and roads makes it necessary to wear shoes of some kind.

Many different materials are used for clothing. The most common are wool, cotton, silk, and linen. *Wool* is a special kind of hair which is most commonly got from the sheep; but other kinds of wool, or hair resembling wool, are also used. Thus alpaca cloth is made from the wool of the alpaca, a South American

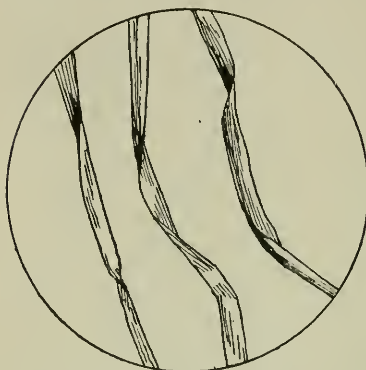


Wool fibres under the microscope. Note the scales, which become locked together and cause the cloth to shrink.

animal of the camel kind, and cashmere is woven from the woolly hair of the Cashmere goat of Central Asia. The chief value of wool as a material for clothing is its power of preventing the loss of heat from the body. It also absorbs moisture and thus prevents the perspiration from causing a chill to the skin. Woollen material is difficult to wash. Much rubbing causes the hairs to become closely locked together, and thus the cloth is apt to shrink and to become hard and stiff.

Cotton is the down which grows on the seeds of

the cotton plant. The fibres are smoother than those of wool, and under the microscope they are seen to be flat and ribbon-shaped. Cotton materials are cheap, and they wear and wash well. They do not absorb moisture as wool does, and heat passes through them much more readily. A soft downy cotton fabric known as flannelette is often used instead of woollen, but there is considerable risk in its use, as it is very inflammable unless specially treated with chemicals. Many fatal burning accidents have happened, especially to children, from the wearing of flannelette garments.



Cotton fibres under the microscope ; they are smooth and flattened like ribbons.

Silk is a fibre spun by a moth which is usually called the silkworm. When the animal has completed its caterpillar stage of life it wraps itself up in a case or cocoon made of this silk fibre, which it spins from the substance of its own body. When placed under the microscope the silk fibre looks very smooth and glassy. Silk, like wool, is excellent for preventing the loss of

Cotton plant. Note the fibres coming from the bursting pod.

heat from the body, but it is too expensive to be generally used. It is much prized for its beautiful glossy appearance, and on this account many cheap imitations of silk have been invented. Cotton can be treated with chemicals so as to resemble it very closely.

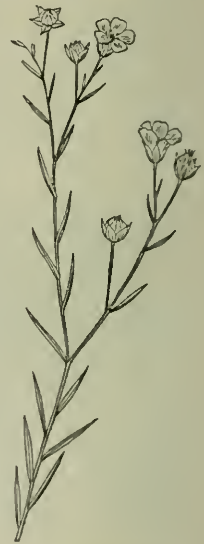
The moth which yields Tussur silk.

Linen is made from the fibres in the stem of the flax plant. The stems are steeped in water to cause the soft green parts to rot away. The fibrous part is then beaten and combed out in order to obtain soft thin fibres suitable for spinning and weaving. As a clothing material linen resembles cotton, but it is much more durable and more expensive. It does not absorb moisture or prevent the loss of heat to any great extent. Its smoothness and whiteness make it specially suitable for such articles as collars, and the strength and fineness of its fibre enables it to be worked up into lace and other decorative forms.

Italian silkworm; caterpillar feeding on mulberry leaves.

Leather is a specially prepared form of the skins of the larger animals such as the ox and the sheep. It is now chiefly used for boots and shoes. In former times leather was also used for the outer garments of men engaged in certain kinds of work, and it is curious to note that the use of motor cars has again led to a similar employment of leather. It is now much used for the lining of overcoats, as it is the best material for protection against cold winds. Smaller skins yield leather suitable for gloves. To make leather, the skins have the hair removed, and are then cured by *tanning*, as it is called. This is done by steeping the skin for a long time in water containing oak bark, which preserves it from decay and makes it tough and waterproof without being hard. Inferior qualities of leather can be produced much more quickly and cheaply by the use of other tanning materials.

Silkworm cocoons—one opened to show the animal inside.



The flax plant.

The skins of certain animals are cured and used for clothing in the form of *furs*. For this purpose the hair is left on the skin either in its natural form or artificially trimmed so as to improve its appearance. Fur-

bearing animals are found only in cold countries, and owing to the demand for their skins their numbers are being continually reduced by hunting and trapping, while the price of furs is rising year by year. On this account attempts are being made to breed fur-bearing animals in a more or less domesticated state, and fox farms have been started in Prince Edward Island and elsewhere to supply the fur of the fox, as the ostrich farms of South Africa now supply the markets with ostrich feathers. Many beautiful furs, such as those of the sable, ermine, and silver fox, are too expensive for any but well-to-do people. The hair of the common rabbit, and of cows and horses, is sometimes pressed together and beaten into thin sheets, and it then forms the substance called *felt*, which is much used for hats.

Garments made of loosely-woven or knitted fabrics have come much into use in recent years. The advantages of such "cellular" garments are that they are elastic and yield to the movements of the body, while the looseness of the fabric leaves spaces for what we might call a layer of air-cells. This air contained in the material makes it "warmer" than if it were closely woven. Such garments also permit of the passage of moisture through the cloth.

The quantity and the kind of clothing which should be worn differ so much under different circumstances that only very general rules can be given. There are some qualities, however, which must be found in all good clothes—that is, all clothes which provide the necessary protection for the body and are not in any way injurious to health. There are also common faults in clothing which we must learn to avoid.

It is evident that our clothing should allow of the free movement of all parts of the body. Any tightness round the lower part of the chest is particularly harmful. The lower ribs must have freedom of movement if breathing is to be rightly carried on. The fashion of the "wasp waist" was a harmful one, as it interfered with natural breathing,

Dressing baby after his bath—a lesson for little mothers.

and it is fortunate that an absurdly small waist is no longer considered by women to be elegant and fashionable.

The foot probably suffers more from "pinching" than any other part of the body. Corns, ingrowing toe nails, misshapen toe joints, and an awkward style of walking are the most common consequences of wearing tight shoes. Children's shoes ought never to "fit," in the usual meaning of the word; they

should always be "too big," in order to allow for growth as well as free movement of the foot. Many a badly-shaped foot is due to the wearing of "neat" shoes during childhood or youth. The absurdly small, shapeless, and useless feet formerly fashionable among the women of China were produced by tight bandaging of the foot during childhood.

No part of the clothing should press so tightly on the body as to interfere with the free circulation of the blood. A tight collar impedes the flow of blood to the head. Tight garters or tightly-laced shoes make the feet cold by checking the free flow of warm blood through the lower limbs.

Clothing should be loose enough at all points to allow air to pass to the skin. It should not be too heavy, nor should too many garments be worn. Doctors who examine the health of children at school usually find that the young people are much more commonly overloaded with clothing than too lightly clad. A school nurse recently found that a child was wearing sixteen layers of clothes.

There is one old mistake regarding children's clothing which was once very common, and has not yet entirely disappeared in some places—namely, that young children ought to be "hardened," or accustomed to endure cold. In order to do this, children were—and sometimes still are—dressed so as to leave the arms and knees bare even during very cold weather. It is true that the skin does with practice become accustomed to changes of temperature, but in the case of young, growing children "hardening" is a mistake. Children lose heat easily, and the undue exposure of their body to cold is hurtful to their

health and growth. In cold weather their limbs should be covered lightly but warmly.

While wearing too little clothing gives rise to chill, the same result follows from wearing too much. When the skin is kept too warm it is always moist with perspiration, and this makes it "soft" and liable to suffer from cold.

The weight of the clothing must be supported in a suitable way. Formerly it was the habit to have much of its weight hung from tight bands round the waist. At present there are many who say that all clothing should be hung from the shoulders. That is certainly a much better plan. But a doctor who has had occasion to examine a large number of school girls dressed on this plan found that in many cases their shoulders were being marked by the tight bands which kept their garments in position. It is no more reasonable to have tight bands pressing on the shoulder than on the waist. If a garment hung from the shoulders weighs down the chest, it is wrongly suspended. The weight should be distributed so that no part suffers, whatever may be the special plan adopted.

Waterproof garments are now in very common use. In heavy rain, and if worn only for a short time, they are convenient and may be safely used. They should never be used except when needed, however; if worn for a considerable time they are objectionable because they shut in all perspiration and keep out air. Some of the "waterproofed" materials are better because they are not air-tight, although they are close enough to keep out a heavy shower of rain. Rubber overshoes or goloshes are very useful also to keep the feet from dampness, especially when

"The loose flowing robes of the East" (p. 292).
The courtyard of an inn. Note the tent-like covering over the saddle of one camel, to screen a lady rider from view.

shoes made of badly-tanned leather are worn. They have the same disadvantages as waterproofs, however. They retain the perspiration, and if worn long they are often the cause of the "damp feet" which they are meant to avoid.

The washing and cleansing of clothing is very important. Under-garments must be changed and washed at least once a week. Unless this is done, the garments retain the perspiration and waste matter given off by the skin. Sleeping in the under-garments which have been worn during the day is a very unhealthy habit. Every article of clothing should be changed before one gets into bed. In this way the day clothes are aired, dried, and freshened during the night, and the night garments are similarly treated during the day.

CHAPTER XXVI

COMMON ACCIDENTS

Holland is one of the most interesting countries of Europe. It is a small country, but it holds a very honourable place among the nations, and it has played an important part in the history of the world. Its people are hard-working and thrifty, and their cleanliness is proverbial. One of the ways in which they have shown their industry and thrift is in reclaiming land from the sea and cultivating it. The land is so flat that great stretches of it would be covered by the sea at high tide, but the people have built strong mounds of earth to keep out the sea. These mounds are called dykes. The dykes must be carefully looked after and kept in repair. A small opening would let in a stream of water which would soon wash away the dyke, and the sea would flow in and cover the farms and houses and villages.

A story is told of a Dutch boy, Peter, who had been sent on an errand by his mother, and was returning home in the evening along one of these dykes. He heard a sound as of trickling water, and went to see what it was. There in the side of the dyke he found a tiny stream coming through a small opening in the dyke. Young though he was, Peter knew what this meant. He knew that the running water would soon

wash away the earth and sand until the small hole became a bigger one, and that the rush of the water and the beating of the waves outside would make a gap in the dyke, through which the sea would pour in and flood the land. The only way to save the dyke was to stop that little stream of water.

It was a lonely place, and no houses were near. The boy knew that if he went to seek help the hole might be too big for mending before he got back. Just then it was so small that he could stop it with his hand. The only plan was for him to stop the hole and hold back the dangerous trickle of water till some one should come to his aid. So he stopped up the hole, holding his hand against it, and sat down to wait. No one came. Cold and tired and hungry, he sat all night at his post. All night, too, his mother waited for Peter, not knowing what had happened to him. In the morning search was made for him, and the brave little fellow was found, and was soon relieved from his task. The dyke was at once mended, and so the country was saved from ruin. The gallant little Peter was praised as a hero.

When we read such a story as that, we feel proud of a boy who had the forethought and the courage to do so noble a deed. Perhaps we feel that we too could be heroes if only we got the chance. But there are no dykes where we live; we have no chance to stop up a hole as Peter did, and to hold back an ocean with one hand. Yet we have just as good opportunities of doing brave and useful things. Probably Peter never imagined that he was a hero. He had no thought of doing anything great. He simply saw a hole that must be stopped up at once, so he stopped it till some one should come along who could mend it properly. It is

often the little things that count for most. Things that very few people will ever know of may require just as much courage to do as the great things that everybody speaks of.

But we need more than courage if we are to be of use in any sudden emergency. Like little Dutch Peter, we must *know what to do.* Some people are always ready to get into a fuss and insist on "doing something." If we do not know the right thing to do, it is far better to do nothing. At any rate, we can keep quiet, and not hinder those who do know how to act. Even this needs some practice. Self-control, as we have seen, is a thing which comes by practice and habit, and in any sudden emergency the want of self-control may make things worse than they need be.

Suppose that a street car is passing along, and a child suddenly runs out from the side-walk and tries to pass in front of the car. For a moment every one's heart stands still with a sudden fear that the child will be killed. It is almost certain that some of the people who see the danger will shriek with horror. They may even be rather proud of having done so; it shows that their feelings are so quick and sensitive compared with those of other people. In the meantime the car driver has managed to stop his car just in time, while some one who did not shriek or wring his hands has darted forward and rescued the child from its dangerous position. Only these two things could be done, and promptness in doing them was the chief necessity. The shrieks of the bystanders could have no effect except perhaps to confuse and so to hinder those who knew how to act.

There are many times when little accidents occur which call for prompt assistance, and boys and girls

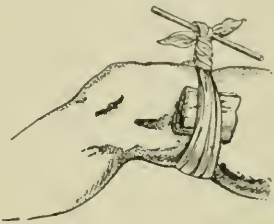
can often give such aid as will save serious trouble, or even save some one's life. But if they are to do this, they must first learn what is the right thing to do in the case of the more common accidents. They must also practise self-control, so as not to be found among those who stand and shriek instead of acting. When serious accidents happen, they may be able to do nothing. Only those who have special training and skill, such as doctors and nurses, can know how to deal with these. But by far the greatest number of

"*Press on the bleeding point with your finger*" (p. 309).

accidents are slight ones, which timely help will prevent from becoming serious.

There are many common accidents which cause *bleeding*. When any part of the body is cut, some of the blood-vessels are cut through also, and blood escapes. Some people make a great fuss at the sight of a few drops of blood, and either faint or get too excited to give any help. If a person is in ordinary health, the loss of a little blood from a cut finger does not matter much. But you can never tell how much blood is going to be lost, and so it is important to stop all bleeding at once. The blood that runs from the cut is being lost from the body, and a great loss of blood may mean loss of life.

The blood, as you know, flows through blood-vessels, and if any is escaping it is coming through some opening in one of the blood-vessels. The first thing to do, therefore, is to stop up this opening in the vessel if you can get at it. This you can usually do by pressing on it so as to stop the flow. You know that blood clots when it escapes from a vessel, and in a small wound the clot tends to close up the opening and stop the bleeding. If the wound is larger, the heart keeps pumping the blood through it, and you can only stop the flow by pressure. In such a case you must either press on the bleeding point with your finger, or you must bind the part so tightly that the blood ceases to flow. Whenever bleeding is severe you must send for a doctor at once. Not a second must be wasted. Until he comes, keep the blood-vessel closed by pressing on it.



A pad placed on a bleeding point, and pressure applied by twisting the bandage tightly by means of a stick.

Cuts are very common accidents among children. A cut may be due to playing carelessly with knives or scissors, or with anything sharp. The first danger of a cut is from loss of blood, and bleeding must be stopped at once, as we have said. Another danger comes from the possibility of germs getting into the wound. These germs may cause it to form *pus* or "matter," and in this way a simple cut may give rise to serious illness. It is very important, therefore, to keep a cut clean. This can be done by careful and thorough washing. Some substance which kills disease germs or a germicide, as it is called, may be mixed with the water with which the wound is

washed. It must then be covered or bound up so as to keep out dust or dirt.

Children sometimes suffer from *bleeding at the nose*, and a very slight cause will often occasion this. Cold helps to stop this bleeding. A good plan is to lay a handkerchief, soaked in cold water and folded, over the bridge of the nose. Ice is still better. The head must be kept up, as that makes less blood flow to the nose. Sometimes it is useful to apply cold to the back of the neck, by means of a wet handkerchief or of ice. An old-fashioned remedy was to put a door-key on the back of the neck; door-keys used to be much larger than they usually are now, and the reason for this remedy was simply that the big iron key kept the neck cold.

A *sprain* is not an uncommon kind of accident. You know that a joint is the meeting-place of two or more bones, and that these bones are bound together by strong fibrous bands. When a sudden strain is put upon a joint, as sometimes happens when one stumbles or falls, the wrench may pull these bands out of place. This is what we call a sprain. The joint becomes swollen, and may be very painful. A sprain may be very slight or it may be severe. A simple way of treating a sprain is to hold the joint for a while in a stream of cold running water or under a water tap. It should then be covered with cotton wool and bandaged. A sprained joint must not be kept bandaged so long that it becomes stiff. It should be moved gently every day.

A *bruise* is caused by a blow or knock from something hard. This injures the small blood-vessels under the skin and causes the part to swell and to become discoloured. If the skin is broken, it must

be kept very clean to prevent the entrance and growth of disease germs. When the skin is not broken, a bruise requires the same kind of treatment as a sprain. Cold cloths should be applied, and the part should be allowed to rest, with occasional gentle movement.

Burns and *scalds* are common forms of accidents among young children. A burn is produced by dry heat, as, for example, by a hot iron or a flame. A scald is caused by some hot liquid, such as boiling water. In both burns and scalds the surface of the skin is destroyed by heat, and extreme suffering often follows. In England, where rooms are usually heated by open fires, many fatal burning accidents have been caused by children's clothes catching fire, and recently a law was made forbidding any one to leave a young child alone in a room unless the fire is protected by a fireguard.

When a burn or scald is large, it requires immediate treatment by a doctor. In houses where there are young children it is a good plan to keep in a box, ready at hand, a simple dressing for occasional accidents of this kind. For this purpose pieces of lint cloth or old clean linen are used. On these is spread an ointment consisting of equal parts of boracic ointment and vaseline, just as butter is spread on bread. Two pieces of the cloth are then laid with the ointment sides together until they are required, when the injury can be treated without a moment's delay. The cloth is laid on the burn or scald with the ointment next the skin. It is then covered with cotton wool and bandaged. Sometimes the pain of a burn can be greatly eased by holding the part in hot water. The water should be boiled, and should then be allowed to cool until the heat can be borne. We must remember that

In a burn or scald the skin is damaged and may be destroyed. Germs may, therefore, enter through the break in the skin, and the greatest care must be taken to keep the injured surface entirely clean.

We have already mentioned that many burning accidents have been due to the use of flannelette as a clothing material for children. It is cheap, but it flames up like matchwood if it is touched with fire. The plan has recently been adopted of treating it with a chemical substance which makes it much less inflammable, but in the old form it should never be used.

If you should happen to be in the room with a child whose clothes catch fire, you may be able by prompt action to avoid a very serious accident. The best way to put out the fire is to wrap something quickly round the child so as to smother the fire; a thick rug or a blanket is best. If there is nothing at hand, roll the child on the floor. The fire may often be put out in this way, and in any case it prevents the flames from rising to the face of the child. Remember at the same time the danger of setting your own clothes on fire. It would be a poor way of helping to have two persons in flames instead of one.

A *faint* is a sudden loss of consciousness due to the want of blood in the brain. One who faints should be laid flat on the floor so that the blood may flow easily to the head. The clothes should be loosened, and the face bathed with cold water. When smelling salts are at hand, a whiff of their pungent odour sometimes helps. A faint generally passes off in a short time. A person who faints should consult a doctor without delay in order to find out what has caused the faint. It is very foolish to faint again and again and do nothing to have matters put right. A perfectly healthy

person does not faint, and it is our duty to be perfectly healthy if we can. Sometimes a girl says, "I often faint," as if that were something to be proud of. She should rather say, "I must try to find out what is wrong and attend to it, so that I may never faint again."

Sometimes one feels faint in a crowded meeting or a close room. His best plan is to get outside into the fresh air as soon as possible. If he feels too faint to walk, he should sit down and bend forward with his head between his knees. In this way the blood is assisted to flow to the brain, and the faint may be avoided.

An attack of unconsciousness together with violent twitching and contraction of the muscles is known as a *fit*. The treatment during the fit is the same as that for a faint. Sometimes when a person is in a fit his tongue is apt to get seriously bitten by the clenching of the teeth. This can be prevented by holding something, such as a cork, between the teeth, but care must be taken that it does not slip into the mouth and cause choking. A fit shows that something is seriously wrong with the health, and a doctor should always be consulted by one who suffers from fits.

Frost-bite is an injury caused by intense cold checking the circulation of the blood in some part of the body. *Chilblains* are due to the same cause, but not in so extreme or sudden a form. Frost-bite should be treated by gentle rubbing with snow—where the snow crystals are hard, with a fur glove—until the circulation is restored. Warmth should not be applied, as it causes a painful smarting of the skin. Chilblains may be treated in the same way, but a wiser plan

is to try to prevent them by using roomy boots and loose warm clothing, by taking plenty of exercise, and eating a sufficient quantity of fatty food.

Sudden illness may be due to great heat as well as to great cold. One who is exposed to the direct rays of a hot sun may suffer from *sunstroke.* Such exposure should be avoided as far as possible, and a light, well-ventilated hat should be worn when one is out-of-doors. Even when we keep out of the sun, great heat often causes exhaustion and illness. We can do a good deal to prevent this by having as much fresh air about us as possible, by taking frequent baths, and by drinking a sufficient supply of cold water.

When a person suffers from sunstroke, the skin feels dry and hot. He should be helped to some shady place, his clothing should be loosened, and cold water poured over his head. When exhaustion is caused by heat, the person is pale and collapsed. He should be treated as if he were in a faint, but warm water should be applied to his face, and hot milk or water given him to drink.

Choking is not an uncommon accident with young children. They may choke on pieces of food which they are eating too hurriedly, or by foolishly putting objects such as marbles or coins into their mouth. Suddenly the child finds that the object has "stuck in his throat." A simple and useful plan is to slap the child smartly on the back as he bends the body forward, and this is often all that is required. If that does not cause the removal of the object, we can put a finger into the child's mouth until it touches the back of the throat. This gives rise to the act of vomiting, and the obstruction is generally expelled by this means from the throat. Children should be warned

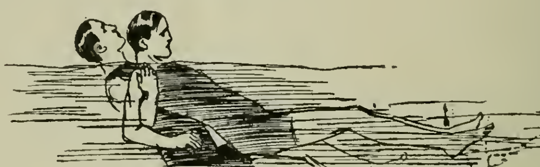
against putting into their mouth things which ought not to be there. If they do not cause choking, they may be swallowed and give rise to serious trouble.

Children sometimes push small objects, such as a bead or the end of a pencil, into the *nose* or the canal of the *ear*. If such objects do not come out easily by bending the head and slightly shaking it, the best plan is to leave them in until we can get the assistance of a doctor. It will do no harm to let them remain for a short time, but we might do much damage to the lining of the nose or to the drum of the ear by clumsy efforts to remove them.

Gritty particles sometimes blow into the *eye*, and are very troublesome until they are removed. Engine-drivers are said to treat this kind of accident by rubbing the other eye. This makes both eyes water, and the particle of grit is usually washed out. We should never rub the eye into which the particle of dust has been blown, as this is apt to press the rough particle against the surface of the eye and injure it. If the dust cannot be removed easily, it is better to go to a doctor than to work much at the eye. Even a slight injury to the clear front part of the eye may cause permanent damage to the sight.

Drowning accidents are unfortunately very common. Every summer the newspapers contain almost daily accounts of people who lose their lives by drowning, or get into serious danger when bathing. Many of these accidents would be avoided if all boys and girls learned to swim. Still more lives would be saved if they could not only swim but also knew how to rescue the drowning. Many boys and girls who were still at school have had the skill and the courage to jump into the water and rescue a drowning comrade.

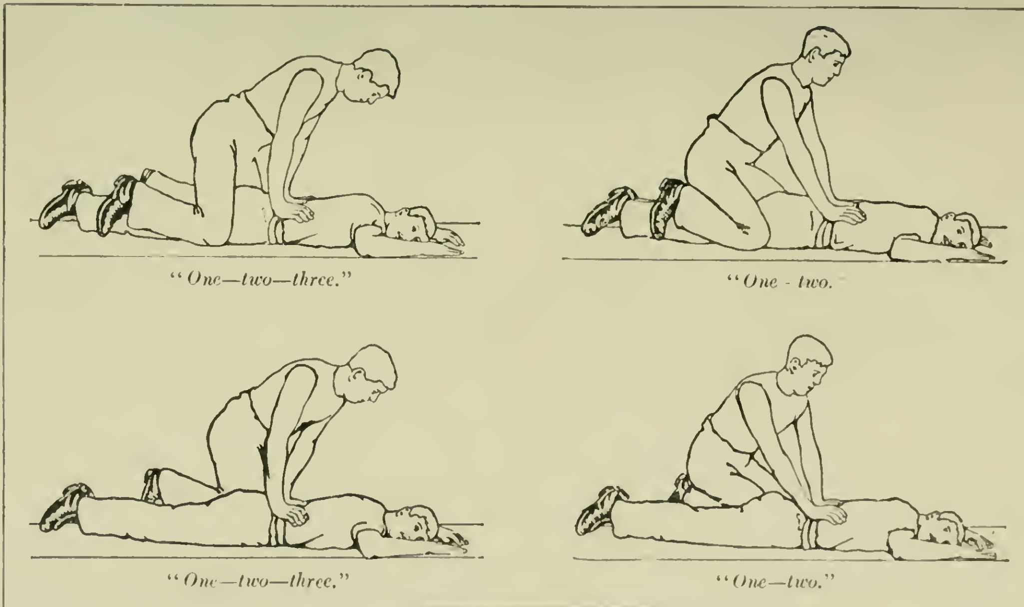
It is not enough that we should know how to support a drowning person in the water and bring him to land. We should also know how to restore him to consciousness if he has stopped breathing and is apparently drowned. It must be remembered that though a person may show no signs of life, and may have been under water for several minutes, it is still possible to restore him. Drowning is really due to a want of air in the lungs, which sometimes become filled with water instead, and what is needed to revive the person is to get air into his lungs and to restore the movements of breathing.



A good method of rescue. Seize the drowning person from behind to prevent his clutching you, and swim on your back, as shown in the sketch.

Several methods of *resuscitation*, as it is called, or restoring breathing by artificial means, have been invented, but none of those in use in former times were simple enough to be used in every case of accident. A few years ago a new method was suggested by Professor Schäfer of Edinburgh University. This is now known as the Schäfer method, and has been very widely adopted on account of its simplicity and the good results which it has produced. It is so simple that any boy or girl can carry it out without assistance. Let us see what this method consists in.

First lay the apparently drowned person flat on the ground, face downwards; the head should be turned to one side so that the mouth and nose may be clear



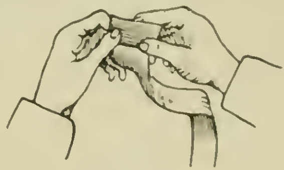
The Schäfer method of resuscitation—kneeling astride the patient, as in the upper figures, or kneeling beside him, as in the lower.

of the ground. You must not stop to loosen his clothing, as every moment is precious. Then kneel astride the person's body, or close to one side of him, with your face towards his head. Place your hands flat on either side of his spine, resting on his loins and lower ribs, your thumbs parallel to his backbone and nearly touching one another. Then you are in the right position to begin work.

Now swing your body forward, keeping your elbows straight, so that your weight falls upon your hands, pressing them firmly down upon the patient's body. This part of the operation lasts while you count slowly *one, two, three.* Then swing your body backwards to the position from which you started, leaving your hands in position, but removing your weight from them. This part of the process lasts while you count slowly *one, two.* The forward swing is then repeated without a pause, and is immediately followed by the backward swing, each double movement taking about five seconds, or being repeated twelve times in the minute. The movements are easy, and you can continue them for an hour without fatigue if necessary. You must not give up, indeed, until you have worked for at least an hour without a pause, or until natural breathing is resumed by the patient.

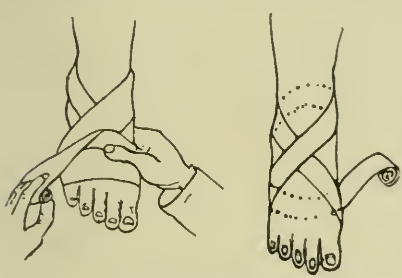
You can see at once the use of these movements. When your weight presses upon the patient's back and loins, the lung space in his chest is made less, as it is in your own chest when you breathe out. When you relax the pressure, the different parts of his chest spring back to their former position, and some air is drawn into the lungs. So with your "*one*, two, three; *one*, two," you imitate the natural movements of the chest, and the air drawn into the lungs brings back the

circulation of the blood and restores the "drowned" person to consciousness. In the meantime, no doubt, other helpers will have got ready warm dry clothes and blankets, hot-water bottles or hot bricks, and other things to restore warmth to the body. But the one essential thing is to restore breathing. Nothing must be allowed to interfere with the process of artificial respiration, for without this the patient will never regain consciousness.



Rolling a bandage.

In several of the rules of treatment we have given for accidents you must have noticed that bandaging is mentioned. The most common kind of bandage is known as the roller bandage. This is a narrow strip of cloth, from $2\frac{1}{2}$ to 4 inches wide, which is kept neatly rolled up until it is wanted. In former times careful housewives kept old linen for bandages, and often the same bandage was used again and again. A much better plan is to use bandages made of cheap cotton material, and to burn them after they have been used.



Bandaging an ankle.

It is very important to be able to bandage an injured limb or other part of the body so as to cause no discomfort. The only way of learning this is by practice. The bandage must be firm enough to stay in position and to act as a support and a protection, but it must

not press so much on any part as to check the circulation. It is of great assistance to cover the part with cotton wool before bandaging. This fills up hollows and makes it more easy to put on the bandage smoothly and with equal pressure. In bandaging a limb we should always begin at the lower part and work upwards.

In all cities, and in most country districts as well, there are classes held where people can learn how to treat such simple cases of accident as we have been speaking of. These *ambulance* or *first-aid* classes have done much good. Whenever a street accident occurs there is almost sure to be some intelligent person at hand who has enough knowledge to be of service. Boys often learn very useful lessons of this kind in the Boys' Brigade or the Boy Scout classes. To attend such classes is one of the best ways to prepare ourselves for being of real use, and then we shall not merely stand and shriek when an accident happens.

THE END.